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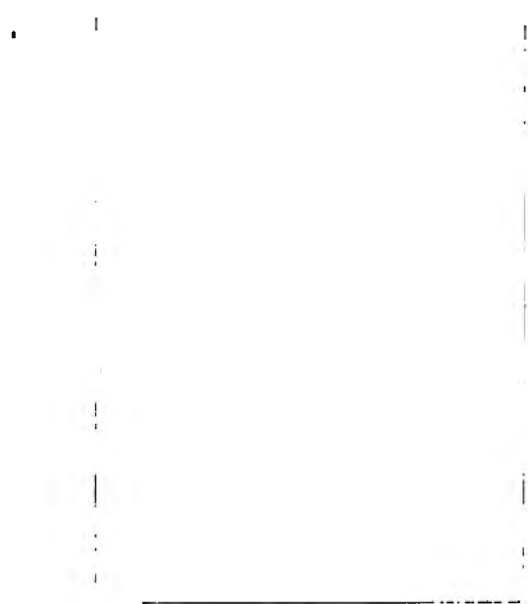
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TWENTY-SECOND
ANNUAL REPORT
OF THE
FISHERY BOARD FOR SCOTLAND,
Being for the Year 1903.

IN THREE PARTS.

- PART I.—GENERAL REPORT.**
PART II.—REPORT ON SALMON FISHERIES.
PART III.—SCIENTIFIC INVESTIGATIONS.

PART III.—SCIENTIFIC INVESTIGATIONS.

Presented to both Houses of Parliament by Command of His Majesty.

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TWENTY-SECOND ANNUAL REPORT.

TO THE RIGHT HONOURABLE
ANDREW GRAHAM MURRAY, K.C., M.P., &C.,
His Majesty's Secretary for Scotland.

OFFICE OF THE FISHERY BOARD
FOR SCOTLAND,
EDINBURGH, 1st July, 1904.

MY LORD,

In continuation of our Twenty-second Annual Report, we have the honour to submit—

PART III.—SCIENTIFIC INVESTIGATIONS.

GENERAL STATEMENT.

This, the third part of the Twenty-second Annual Report, contains an account of the scientific investigations conducted by the Board in 1903 in connection with the sea fisheries of Scotland, so far as these have been completed, by means of the Parliamentary Vote granted for the purpose. The scientific researches have been carried on for the most part at the Board's Marine Laboratory at the Bay of Nigg, Aberdeen, which was erected a few years ago, and where tanks have now been fitted up for various experiments and observations. The sea-fish hatchery is also situated at the same place, and a statement as to its operations during the year will be found below.

The investigations into the condition of the fishing grounds, more particularly in the Moray Firth and Aberdeen Bay, which were commenced four years ago, were continued last year by means of steam-trawlers. One of the chief objects of these investigations is to ascertain the changes in the abundance of the food and other fishes in the closed waters in different years; but observations are also made on the reproduction of the fish, their spawning, food, and on various other points connected with their life-history; and collections of the plankton or floating organisms are secured, and experiments made with small-meshed and large-meshed nets.

With the large trawl, the efficient ship, and the experienced trawlers in charge, it is possible to make a much more thorough examination of the bays than was formerly the case, and from the

fact that the actual trawling operations are carried on exactly as they are in commercial fishing, opportunities are thus afforded for certain observations of importance, as the proportion of the marketable and unmarketable fishes which are caught, and the destruction of immature fish on different grounds and at different seasons.

TRAWLING INVESTIGATIONS.

In the course of the year the results of 148 hauls of the large otter-trawl were recorded, of which 101 were made in the Moray Firth and 29 in Aberdeen Bay, making 130 in the closed waters; and in addition 18 drags were recorded in the waters offshore, the aggregate thus being 148. In the Moray Firth the more important areas were examined in February, March, April, June, October, November, and December, and the grounds in Aberdeen Bay were visited in the same months. The localities in the Moray Firth which were most thoroughly examined were Burghead Bay and the Dornoch Firth, as well as Smith Bank, the grounds off Lossiemouth, off the Suters of Cromarty, and the coast of Caithness.

The total quantity of fish recorded in the course of the investigations was large, viz., 180,515, of which 126,485 were of a kind and size to be marketable, and 54,030 were found to be unmarketable, either because they were of inedible varieties, or too small to be profitably sold. Those which belong to the former category are comparatively not numerous, comprising mostly long rough dabs and various odd kinds, but they may include large numbers of the angler or monk fish and gurnards, though these are very often brought to market. The great majority of the unmarketable fishes belong to edible and saleable forms, and are simply rejected because of their small size, such as small haddocks, whittings, plaice, &c. In the hauls in the inshore waters the proportion of the unmarketable fishes varied from 7·4 per cent. for cod to 78·2 per cent. for gurnards among the round fishes, and from 0·5 per cent. for brill to 89 per cent. for common dabs among the flat fishes. The percentage of unmarketable plaice was relatively large, namely, 30·3, due to the fact that the fishing was to a large extent carried on in shallow water. The proportion of the marketable and unmarketable was found to vary very greatly according to the depth of the water and the season.

In the paper by Dr. Wemyss Fulton, the Scientific Superintendent, on this subject, will be found described also the results of an investigation on the proportion of the marketable fishes which are immature—that is, which have not yet reached a size at which reproduction takes place. The limit between the mature fishes and the immature in respect to size is first dealt with, and it is shown that in most cases it is not the average size of the generation which first becomes mature that is the true dividing line, but something under it, the precise point varying in different species according to whether the reproductive stage is reached early or late in the growth of the species.

The proportion of the immature, whether regarded in terms of weight or of size, of different species brought to market varies very greatly according to the species. Among some flat-fishes, such as

the common dab, practically all that are marketable are mature, this fish becoming reproductive at a small size. Among plaice, on the other hand, which does not attain maturity until it is several years of age and of some size, the proportion of the immature amounts to about twenty-four per cent. of the marketable fishes, but with this species in particular the proportion varies much according to the chief areas of fishing. Among the witch sole the proportion amounts to about fifteen per cent., and it is still less among lemon soles, viz., about seven per cent. From the large size at which the cod first reaches maturity, the proportion of the immature that are marketable is considerable; these comprise codlings, and of the total quantity landed about thirty per cent. are sexually immature. With haddocks, and still more with whittings, the proportion is much less, these species first attaining maturity at about the size at which they become marketable. The calculation in regard to haddocks shows that the proportion of the marketable which are immature is small, amounting to only about one per cent. of the quantity landed, while among whittings it is less, practically all the whittings caught by trawlers which are of marketable size being adult.

It must be borne in mind, with reference to this subject, that the limit between the mature and the immature is a biological one, having reference, not to the size of the fish from the market point of view, but in relation to the size when reproduction begins.

INVESTIGATIONS ON THE RATE OF GROWTH OF FISHES.

In the present Report will be found a paper by Dr. T. Wemyss Fulton describing the results of his further investigations on this subject, in continuation of the researches detailed in some of the preceding Reports. In addition to the measurement of large numbers of fishes obtained during the trawling investigations by the use of a small-meshed net, numerous observations were made to determine the relation between the size and weight of fishes belonging to nineteen species, and a series of experiments were carried on to show the influence of temperature upon growth.

With regard to the ratio between the length and weight of fishes, it might be assumed, without experimental evidence, that their growth was in consonance with the physical law governing the relation of similarly-shaped bodies of uniform specific gravity with regard to weight and dimensions—that the weight increased as the cube of the length, so that a fish which doubled its length should increase its weight eight times. The observations, which have been made on between 5000 and 6000 fishes, show that this law does not apply with exactitude in any of the species examined, the weight increasing in proportion more rapidly than the length, the conclusion being that, if the specific gravity remains the same, growth takes place to a greater extent in some other dimension than in length, whether in breadth or thickness. The various species examined displayed great differences in the relation between the weight and length at a given size, the heaviest in proportion to its length being the turbot, and the lightest the witch, the extremes being found among the flat-fishes.

With regard to the influence of temperature upon growth, it is well known from previous observations that fishes, at least in the waters near the shore, grow less quickly in winter than in summer, and may not grow at all if the temperature be very low. In the experiments referred to a number of the food-fishes were kept in tanks in which the water was of different temperature—in one it was considerably above the normal—and the effect on the growth was determined by measuring the fishes after they had been subjected for some time to the various temperatures and comparing the measurement with what it was at first. With a mean temperature of 40·1 F. it was found that the mean increase in the length of whittings was 1·6 millimetres per ten days, and 2·5 millimetres when the temperature was 48·7 F.; under the same conditions haddocks grew at the rate of 2·7 and 5·1 millimetres respectively, and codlings increased under the lower temperature at the rate of 3·6 millimetres, and under the higher temperature at the rate of 6·87 millimetres in each ten days. In another tank where the mean temperature was 54·5 F., the rate of growth in length in each ten days was, on the average, 2·8 millimetres for whittings, 6·45 for codlings, 3·0 for common dabs, and 3·29 for plaice. The growth in length varied generally in relation to the size of the fish as well as to the species, the smaller individuals as a rule growing the quickest, and considerable difference was exhibited in many cases among individuals of the same species approximately equal in size.

The influence of temperature is exerted directly in connection with the metabolism of the fish, that is, the chemical changes in its tissues, which result in growth as well as in the expenditure of energy. In low temperatures the process of digestion was greatly impaired, and appetite was more or less in abeyance, the fishes refusing their food or eating sparingly. It has been shown that the action of the digestive ferments is suspended at low temperatures and increased at high temperatures. The bearing of these observations on the growth of fishes in winter, whether in the sea or in fresh water, is obvious.

In the same paper the results of the investigations made as to the growth of the Sprat, the Witch Sole, the Norway Pout, and the Sharp-tailed Lumpenus are described, and illustrated by a series of diagrams.

THE HATCHING AND REARING OF FOOD-FISHES.

During the hatching-season of 1903 the number of eggs of the plaice collected from the spawning pond at the Hatchery, Bay of Nigg, was approximately 65,940,000. This was almost the same number as in 1901, and about seven millions less than in the previous year. The number of fry that were hatched from these eggs and retained in the hatching apparatus until approaching the post-larval stage was estimated at about 53,600,000, or a little over 81 per cent. The fry were liberated for the most part off Aberdeen, but on three occasions they were taken further north and liberated off Fraserburgh.

The first eggs were collected on 23rd January and the last on 16th May, the period of collection thus extending over 113 days, but the greater number were obtained in March, when 37,080,000

were collected, the number in April being nearly sixteen millions, and in February nearly twelve millions. It may be stated that the collection of eggs extends over a longer period at the Bay of Nigg than was the case at Dunbar, where the work did not usually commence until March, the average duration at the former being 65 days and at the latter 86 days. The difference is due, not to variation in the spawning season, but to the circumstance that the fishes at Dunbar, being for the most part collected a little before the spawning, did not become accustomed to confinement sufficiently to part with their eggs until the spawning season was some way advanced, while at the Bay of Nigg they are kept in the large pond throughout the year, and spawn under natural conditions approximately during the same time that plaice are found spawning in the sea. An abundant supply of pure sea-water, of suitable temperature and specific gravity, has materially aided in the success of the work; and as mentioned in last year's Report, the cost of the fish hatching, when the hatchery is operated in conjunction with the Marine Laboratory, is materially reduced, and does not exceed £100 per annum.

The period for which the embryonic and larval fishes are protected in the hatching apparatus amounts to about half the duration of their pelagic life, but the benefit would be considerably increased if it were possible to rear them in any large numbers through their post-larval stages—that is, until they have completed their transformation and become adapted to live on the bottom. The rearing is not an easy matter, owing to the difficulty of providing suitable food for multitudes of larvæ confined in relatively small volumes of water, but the attempt to do so will be made by the use of a special tank.

Since the hatchery was established the number of fry of the food fishes which have been produced is as follows:—Plaice, 340,455,000; lemon soles, 5,727,000; turbot, 5,160,000; cod, 4,010,000; and other kinds, 2,000,000—the aggregate being 357,352,000.

During the season deputations of fishermen from Aberdeenshire, who visited the establishment by arrangement with the Technical Education Committee of the County Council, received demonstrations as to the operations and the life-histories of the food fishes.

THE LIFE-HISTORY OF THE CRAB.

In the present Report will be found a paper, illustrated by four plates, in which Dr. H. C. Williamson gives the results of further observations on the life-history of the edible crab and some other Decapod Crustacea. The observations deal mainly with the reproduction, and in this connection with the processes of casting, impregnation, and spawning. The spawning of the crab takes place in November, December, and January, and the casting of the shell and impregnation take place in summer; and it appears probable that in most cases spawning does not follow until about fourteen or fifteen months after the process of casting.

On extrusion the eggs are attached to the swimmerets of the mother, and remain there for about seven months. The mode by which the eggs are attached is of interest, the author having

discovered that they are skewered on to the long delicate hairs with which the inner branches of the swimmerets are provided, and are not, as has generally been believed, fixed to them by a mucilaginous secretion. The eggs themselves are never found cemented together although crowded in close contact. The mode in which the eggs are skewered on to the stiff hairs is as follows. When the eggs are extruded they imbibe sea water and become swollen, so that the egg-mass is separated from the shell, and this space soon attains large dimensions. The eggs are retained in a semi-fluid mass in the "apron" of the crab, and by the continuous stabbing movement of the stiff hairs on the swimmerets the eggs are pierced and skewered as described. Dr. Williamson also treats of the rate of growth, the migrations, and the distribution of the crab, and in connection with the former subject had the use of the data furnished by Mr. Waddington, Bournemouth, of the various successive casts of certain edible crabs which had been kept in confinement for periods up to two years, and these are represented in a series of figures, and are of much interest.

Further descriptions are given of the results of labelling crabs which were afterwards liberated, in order to throw light on their migrations. In contrast to some of the previous results, it may be said that one of the labelled crabs, an adult male, was obtained three years after its liberation very near the spot where it was set free.

THE YOUNG OF THE WITCH SOLE.

During the trawling investigations in the Moray Firth a very complete series of the young of the Witch Sole was obtained, one of the flat-fishes now brought to market in considerable numbers by the trawlers working in deep water, and in the knowledge of whose life-history there were considerable gaps. Dr. Williamson describes these in a paper in the present Report. Some dubiety has existed as to the identity of the post-larval stages of this form, which differ from the corresponding stages of most flat-fishes by their great length and slenderness, as well as by other characters, so that the first one described was supposed to be a young halibut. The present series, by filling up the blanks between the previously-recorded stages, completes the chain connecting the egg with the parent fish. The paper is illustrated with a number of figures.

THE MARINE CRUSTACEA.

In this Report will be found a paper, illustrated by three plates of figures, by Dr. Thomas Scott, descriptive of a number of rare crustacea, obtained for the most part during the trawling investigations. The forms described are all small, and include two groups of the Copepoda that are somewhat abnormal both in their structure and habits. Among the nine species belonging to the first of these groups—the Monstrillidæ—three are new to science and are now described for the first time, and of the seven species which belong to the second of the groups—the Choniostomatidæ—five are new to science and are here described for the first time,

and these are all minute forms which are parasitic on small species of Crustacea.

The occurrence of other rare species belonging to the Amphipoda, the Isopoda, and the Sympoda, other groups of Crustacea, is also recorded.

Apart from the zoological interest of these discoveries, it is to be noted that the minute crustacea with which they deal play an important rôle in connection with the food of fishes, many forms living upon them almost exclusively at some stage or another of their existence.

THE PARASITES OF FISHES.

In continuation of his researches on the forms which are parasitic on marine fishes, Dr. Thomas Scott also contributes a paper to the present Report on this subject, illustrated with a series of figures. The parasites described include four Copepods and two Trematode worms. One of the former is new to science, and the other three have not previously been recorded from the Scottish seas. Both the Trematodes are new to science, and were obtained, along with two of the Copepods, on a specimen of the sting ray (*Trygon pastinaca*)—a fish closely allied to the skates—which was caught in the Moray Firth during the trawling investigations.

In this paper there is also a description of a figure of a post-larval fish which has been attacked by two small crustaceans, furnishing an example of one of the dangers to which young fishes are exposed.

THE YOUNG OF THE CONGER.

In the course of the trawling investigations in the Moray Firth, two specimens of the pelagic young of the Conger-eel were taken in the small-meshed net used around the cod-end of the otter trawl. These forms, which are characterised in their younger stages by their singularly flattened form, are known as Leptocephali, and were until comparatively lately believed to represent distinct species of fish. They are very rarely seen in British waters. The two specimens referred to are described and figured in a paper by Dr. T. Wemyss Fulton in the present Report, along with other rare fishes obtained during the investigations. Among the others may be mentioned a larval Fierasfer, an extremely rare form which, in the adult condition, lives within Holothurians; it was taken in a tow-net easterly from Aberdeen. A specimen of the pilchard was also secured in the Moray Firth—a fish which is said to have been at one time fairly common at some places in the southern part of the East Coast, but is now hardly ever seen in these waters. Other rare specimens comprised the sting-ray and the thickback sole, both secured in the Moray Firth. It is indeed remarkable that in several respects the fauna of the Moray Firth offers resemblances to that of the West Coast; it appears to indicate that a connection is established by means of the sea currents entering the Firth from the north.

INVESTIGATIONS ON THE HERRING IN THE FIRTH OF CLYDE.

In connection with the winter herring fishing at Ballantrae Bank, off the coast of Ayr, arrangements were made for an investigation of the conditions of the fishing in relation to the operation of the Bye-law No. 18, by which the use of the seine for the capture of herrings within a defined area off the coast is prohibited. Owing, however, to the stormy weather that prevailed on these exposed grounds the fishing was almost a complete failure, only thirty-five crans of herrings being obtained within the area specified, although 232 crans were caught in the more sheltered waters of Lochryan, where fishing operations could be carried on. Under the circumstances it was not found possible to make the investigations desired; but it may be noted that the weather conditions made an effective close-time in protecting the herrings frequenting the grounds, and if, as there is every reason to believe was the case, the herrings spawned there in February and March, the result ought to tend to increase the number of herrings in some future season.

Investigations have also been undertaken with regard to the herrings in the Firth of Clyde generally, more particularly in connection with their migratory movements and spawning, about which comparatively little is known, and which will require some considerable time to complete. In reference to this enquiry a research is being made by Professor Milroy, Queen's College, Belfast, on behalf of the Board, as to the chemical composition of the herring in relation more especially to the reproduction of the fish.

We have the honour to be,

Right Hon. Sir,

Your most obedient Servants,

ANGUS SUTHERLAND, *Chairman.*

D. CRAWFORD, *Deputy-Chairman.*

D'ARCY W. THOMPSON.

W. R. DUGUID.

L. MILLOY.

D. MEARNS.

H. WATSON.

WM. C. ROBERTSON, *Secretary.*

SCIENTIFIC REPORTS.

I.—TRAWLING INVESTIGATIONS. By Dr. T. WEMYSS FULTON, F.R.S.E., Superintendent of Scientific Investigations.

INTRODUCTORY.

The investigations into the condition of the fishing grounds, particularly in the closed waters of the Moray Firth and Aberdeen Bay, which were commenced four years ago by means of steam-trawlers, were continued last year, and a voyage was also made to the offshore waters lying off the mouth of the Firth of Forth. In the Moray Firth the more important areas were examined in February, March, April, June, October, November, and December, and the grounds in Aberdeen Bay were visited in the same months. On each occasion the places where fish were found to be most abundant were chiefly worked over; the total number of hauls made in the Moray Firth, the results of which were recorded, was 101, and the number in Aberdeen Bay was 29, making a total in the closed waters of these areas of 130 drags, in addition to 18 in the offshore waters, or 148 altogether. The localities in the Moray Firth which were most thoroughly examined were Burghead Bay and the Dornoch Firth, as well as Smith Bank, the grounds off Lossiemouth, off the Sutors of Cromarty, and the coast of Caithness.

The total quantity of fish taken in the course of the investigation was large, amounting to 180,515 in the completely recorded hauls, and of these 126,485 were of a kind or size to be marketable, and 54,030 were unmarketable and were thrown overboard.

One of the chief objects of these investigations is to ascertain the changes in the abundance of the food and other fish in the closed waters in different years and seasons, but observations are also made on the condition of the reproductive organs of the fish, their spawning, food, and on various other points connected with their life-history; while at the same time the temperature of the surface and bottom water at the various places is observed and recorded; and from the fact that the actual trawling work is carried on precisely as it is for commercial purposes, opportunities are thus afforded for certain observations, as, for example, the proportion of the various kinds of fish captured in the net which are marketable and the proportion unmarketable, the influence of the size of the mesh of the net on the size of the fish caught, &c., which would be otherwise difficult to obtain. Collections of the floating organisms or plankton were also secured, and a number of experiments made with small-meshed nets with the object of procuring collections in connection with the study of the rate of growth of fishes and their distribution.

With the large commercial trawl, the efficient ship, and the experienced trawlers in charge it is possible to make a much more extensive and thorough examination of the grounds than could formerly be done.

The results of the investigation are given in detail in the following pages and in the Tables which are appended.

THE PROPORTION OF MARKETABLE TO UNMARKETABLE FISHES.

As already mentioned, the proportion of the unmarketable to the marketable was 54,030 to 126,485, which is therefore a very considerable

proportion. The unmarketable fishes vary in amount in several ways. There are some which are never taken to market under any circumstances, being inedible or at least unsaleable. The most common of these is the long rough dab, which, however, is not found in any quantity in the shallow inshore waters. Dog-fishes are also unmarketable in the same way, and they are sometimes taken in large numbers by the trawl in the deep water in the northern part of the North Sea, but much less commonly in the Moray Firth or Aberdeen Bay. There are a few other species occasionally brought up in the trawl which are for the same reason never taken to market. But the great majority of the unmarketable fishes belong to forms which are quite edible and marketable and are rejected merely because of their small size, such as small haddocks, whiting, plaice, &c. In some instances the question whether a particular species is taken to market or thrown overboard depends upon circumstances, irrespective of the size of the fish, as, for instance, with gurnards and anglers. These two forms are now, however, generally brought to market, in the latter case only the tail part being made use of. The proportion of the unmarketable fishes of the class referred to depends also to a very large extent on the grounds fished over and the season of the year. Examples of this fact are described in the following pages, as, for instance, in connection with the plaice and haddock (p. 30, 32, 36, 42).

In the accompanying Table I have tabulated the numbers of marketable and unmarketable fishes taken in 103 hauls of the net in the Moray Firth and Aberdeen Bay, and have represented the proportions of each for the various species in percentages of the total.

FISH.	MARKETABLE.		UNMARKETABLE.		TOTAL.
	Number.	Per Cent.	Number.	Per Cent.	
Cod,	4,283	92.5	343	7.4	4,626
Haddock,	46,287	86.0	7,525	14.0	53,812
Whiting,	4,694	57.3	3,495	42.4	8,189
Codfish,	45	91.8	4	8.2	49
Ling,	6	—	—	—	6
Hake,	4	—	1	—	5
Gurnard,	465	21.7	1,675	78.2	2,140
Catfish,	76	100.0	—	—	76
	55,860	81.0	13,043	19.0	68,903
Plaice,	27,669	69.6	12,057	30.3	39,726
Common Dab,	1,779	10.9	14,543	89.0	16,322
Flounder,	904	91.6	83	8.2	987
Witch,	5,089	84.8	911	15.1	6,000
Lemon Dab,	518	95.7	23	4.2	541
Halibut,	6	100.0	—	—	6
Turbot,	23	100.0	—	—	23
Brill,	220	99.5	1	0.5	221
Long Rough Dab	—	—	2,533	100.0	2,533
Sole,	3	—	—	—	3
	36,211	54.5	30,151	45.5	66,362
Skates and Rays, ...	407	55.2	331	44.8	738
Anglers,	173	28.6	432	71.2	605
Other Fish,	—	—	186	—	186
	92,651	68.0	44,143	32.0	136,794

From this Table it will be seen that the percentages for the gross catch of fish are 68 for the marketable and 32 for the unmarketable, and these figures may be taken as fairly well representing the proportions in the inshore waters referred to, although the ratio varies on different grounds and at different times.

The percentage of cod which were unfit for the market by reason of their small size was small, and less than with any other round fish save the catfish; it amounted to only 7·4 per cent., the marketable, including cod and codling, being 92·5 per cent. The proportion of unmarketable haddocks was much higher, viz., 14, as against 86 per cent. marketable; but the proportion was found to vary very greatly in different cases. In the hauls made in Burghead Bay in December, for example, about five-sixths of the haddocks taken were too small to be marketable, while on other occasions the proportion of these small haddocks was very slight.

The proportion of unmarketable whittings taken was still greater, amounting to 42·4 per cent. of the total, the marketable being 57·3 per cent. The unmarketable coalfish—of which, however, comparatively few were caught—amounted to 8·2 per cent., while all the catfishes obtained were of marketable size. Gurnards, which, as stated, are not always taken to market, show a high percentage of the “unmarketable,” partly for this reason, 78·2.

The proportion of round fishes of edible and saleable kinds which were unmarketable was collectively 19 per cent., the marketable being 81 per cent.

With flat-fishes, apart from the long rough dab, which is never taken to market, the highest percentage unmarketable were among the common dabs, viz. 89, the marketable being only 10·9 per cent. This is owing to the generally small size of this fish, and sometimes trawlers are not very particular about it, when they are getting good catches of more valuable kinds. The proportion of unmarketable plaice was also high, 30·3 per cent., and in this case, even more than with the haddocks, the proportion varied greatly according to the depth of water and the season. In some places, as at Burghead Bay, where the fishing was as a rule conducted in water over seven fathoms in depth, comparatively few small unmarketable plaice were caught, while in the Dornoch Firth, in from five to eleven fathoms, in June, the majority of the plaice got were too small to be marketable. In two hauls here, of a total of 9649 plaice caught, no less than 6419, or 70·1 per cent., were unmarketable.

The proportion of unmarketable flounders taken was comparatively small, 8·2 per cent., no less than 91·6 per cent. being large enough to be taken to market. The reason of this high proportion is that these flounders were almost without exception spawning fish which had migrated out from the shallow waters near the beach for the purpose of spawning, the smaller and sexually immature forms remaining inshore beyond the reach of the trawl. The same reason no doubt explains the fact that all the turbot and almost all the brill taken were also large enough to be marketable. The number of turbot was not great, 23, but of the 221 brill all but one were marketable, or a proportion of 99·5 per cent. The shape of both these fishes makes them eminently liable to capture in the trawl-net, if they are on the ground, and there is little doubt that the smaller forms, under about nine or ten inches, are close inshore on the sands.

Among the skates and rays 44·8 per cent. were unmarketable, and 55·2 per cent. marketable, and the other unmarketable fishes were made up of anglers, herrings, sprats, dragonets, and a few others.

The number of hauls on the offshore grounds was comparatively small last year, and the same contrast is therefore based on fewer results. Of

a total of 27,156 fishes in the completely recorded hauls, 22,051 were marketable and 5105 unmarketable, the percentage of the former being 81·2, and of the latter 18·7—the proportion of the unmarketable being thus considerably under what it was on the inshore grounds. In these series of hauls also all the gurnards were classed as unmarketable, while, on the other hand, owing to the depth of water, all the plaice were marketable.

The proportion of cod, including codling, which was marketable was 77·2 per cent., 22·8 per cent. being unmarketable; in the case of haddocks, the percentage marketable was 86·7 and unmarketable 13·3; while with whittings the respective proportions were 54·4 and 45·6 per cent.

THE PROPORTION OF IMMATURE FISH LANDED.

The information given above and detailed in the Tables as to the proportion of fish of the different kinds which are caught in the operations of commercial trawl-fishing and thrown away as unmarketable, enables an opinion to be formed as to the degree of destruction which may take place on the inshore grounds.

It is also of some importance to be able to ascertain the proportion of the fish caught and landed which are immature, that is to say, which have never developed milt or roe and reproduced their species. In most cases it may be said that the greater proportion of the unmarketable individuals of the class which is unmarketable owing to the small size, are immature, although in some instances mature fishes may also be too small to be marketable. This is the case with the common dabs, none of the immature individuals being large enough to be marketable, and those landed are therefore adult fishes which have either reproduced or are large enough to reproduce. The same is true of the flounder, which, however, is not taken often in the trawl in ordinary commercial fishing. It is also true to some extent of the haddock, and still more of the whiting, comparatively few of these under the size at which maturity may be reached being brought to market, and with the whiting, at all events, there is no doubt that a fairly large proportion of the smaller-sized but mature individuals are rejected because of their small size.

With plaice, on the other hand, as with turbot, brill, and halibut, all those which have arrived at the size of maturity, and a large number which are under that limit are eminently marketable. It is the same with the cod and the large round fishes, and it is thus of some importance to be able to show approximately the proportion of the mature and immature fishes of the different species which are under ordinary circumstances brought to market.

In order to do this it is necessary to obtain two classes of facts—the limit of size which separates the mature from the immature in the different kinds of fish, and the numbers of fish at the various sizes which are caught. Information on the former head, as I have elsewhere pointed out, is not as exhaustive as one would like, but, still, numerous observations have been made in Scotland and other countries which enable one to differentiate, sometimes with precision and at other times broadly, the mature from the immature. It happens, however, at all events in the case of some fishes, that the size which separates the mature from the immature is not the same in all places. Thus, with plaice the limit between the mature and immature is higher in the northern parts of the North Sea than the southern parts and the Channel. This difference does not, however, affect the present investigation to any extent, because comparatively a very small proportion of the fish landed at Aberdeen is

caught in the southern parts referred to, as is explained in my paper dealing with the statistics in connection with the place of capture in the Board's Twentieth Annual Report.*

For the purpose referred to, certain sizes have been selected as separating the mature from the immature individuals of the various species of fish dealt with; in several instances they exceed the sizes assigned in my earlier papers on the subject,† where the limit had reference rather to the smallest mature individuals which were found than to the average size of the group or generation on first attaining maturity. The latter, no doubt, is the preferable course in many cases, but not in all, as is sometimes supposed.

The subject, indeed—the fixing of the line to separate the mature from the immature, so as to include as few of the latter with the former as possible and *vice versa*—is not by any means as simple as it looks. It is really in some degree a complex problem, and the degree of complexity varies in different cases. If the reproductive generation—that is, the group which first attains maturity—were distinctly separated from the next younger generation or group, then the proper limit would be naturally the point between; on one side all the fishes would be immature and on the other side all would be mature, and in such an example the proper limit would be, not the average size at first-maturity, but the size of the smallest mature fish that could be caught. On the other hand, if the first reproductive generation were so fused with the next younger generation—if the over-lapping between the two was such—that it contained, within the range of its sizes, as many immature as the other contained mature, then the proper limit would be the average size at first-maturity. I am not aware of any case in which either of these two conditions occur. In some forms in which reproduction takes place at an early age, as with the whiting and the sprat, the over-lapping of the reproductive generation with the preceding generation is comparatively slight, and in such instances the preferable limit in my opinion is not the average size of the group which is mature—which would exclude a large proportion of the mature fishes and include a very small proportion of the immature in compensation—but a limit placed near the minimum size at first-maturity.

The approximation to the other extreme is to be found in the larger forms, such as the plaice, cod, &c., where reproduction does not take place at an age so early, and where, consequently, from the variations in the rate or growth of the individuals of the different groups or generations, the first reproducing generation becomes to a certain extent fused with the generation immediately preceding. But I do not know of any case in which the fusion is so complete that half of the fishes comprised within it are mature and the other half immature. With the plaice, for example, a study of the curves appended to my paper dealing with the growth of this fish in the Twentieth Annual Report‡ will show that although a considerable number of the fishes belonging to the younger group next to the reproductive group have fused with the latter, the greater number by far are distinct, and in such instances it appears to me that the proper line of division is not the average size of the reproductive group, but the point between the two groups, *i.e.* where the numbers of immature forms contained within the latter is balanced by the number of mature forms contained within the former.

The precise differentiation of the mature from the immature is further complicated by the circumstance that the males and females do not in all

* Part III., p. 80, Pl. I.

† Eighth Annual Report, Part III., p. 160; Tenth, *ibid.* p. 240.

‡ Part III., Pl. XIV.

species grow at the same rate, or attain the same size, the females, as a rule, growing quicker and becoming bigger; and the numbers of the sexes in proportion to one another may vary. Thus, among the flat-fishes the females grow more rapidly, as a whole, than the males, and reach a larger size; while among the gadoids the rate of growth and the relative dimensions of the older forms appear to be, as far as ascertained, nearly or quite uniform. This does not, however, very materially affect the question of the limit at first maturity, since the males and females grow with fairly equal uniformity until the reproductive stage is reached, but in certain cases the male becomes mature at an earlier age than the female and at a smaller size, and it is this which introduces complexity and difficulty. It thus happens that among flat-fishes many more females than males are landed, although the number of males at the stage of reproduction may be equal to or greater than the number of females on the fishing grounds.

I have therefore prepared a statement of the limit between the mature and the immature fishes of the various species, based upon the available information, with consideration of the facts concerning the growth of the fishes, which may be used in endeavouring approximately to determine the proportion of the immature and the mature which are marketable, as follows:—

Whiting,	-	8½	Turbot,	-	17
Haddock,	-	11	Brill, -	-	15
Cod,	-	26	Common Dab,	-	6
Plaice, -	-	15	Witch,	-	12
Lemon Dab,	-	10			

With regard to the other point of the investigation, the proportions of the fish at different sizes and weights which are landed, I have for a considerable time past devoted attention to this subject, and have measured and weighed a large number of fishes, amounting in the aggregate to over twenty tons, as they are landed and sold. With some kinds the average size and the limits of size are very regular, and these as a rule belong to the more important species. The information thus obtained as to the size and weight of the various classes of fish enables a close approximation to be made as to the proportion of the mature and immature, and thus a comparison instituted between these results and the observations made on board the trawlers on the same subject. Tables containing the particulars of the size and weight of the fish referred to will be found appended to this paper (p. 89), and other information relative to the size and weight is given in a paper on the rate of growth of fishes (*see* p. 142).

I have therefore made a series of calculations to show the proportion of the mature and the immature fishes of certain kinds caught by trawlers, the data being contained in the Tables and in preceding reports of the Fishery Board, particularly the paper above referred to, and the limit of size between the two classes being the biological one as defined.

There are marked differences in the proportions among different fishes. As already stated in the case of the dab, all those which are marketable are of mature size; no immature individuals of this species are, therefore, landed. Among plaice, all those classed as large, or firsts, are of adult size, while all those belonging to the third, or small, class are under the biological size and are immature. Among mediums a certain proportion are immature, rather under one half in number being under the limit of

maturity. When calculated out it is found that approximately 24 per cent., or about one quarter of the total marketable plaice, by weight, are under the limit or immature. The proportion with the plaice varies greatly according to the depth of water, and the figure given offers a contrast to what obtains in the southern and eastern parts of the North Sea.

Among lemon dabs all those classed as large, or firsts, are over the biological limit of maturity, but a fair proportion of the second class, or smalls, are immature, the percentage being about seven for the total weight of the marketable fishes.

Among witches, all those classed as firsts, or large, are over the limit of maturity, and have either spawned or are large enough to do so. Among the class of seconds, which range in size from a little over 8 inches to about 14 inches, with an average length of, approximately, $11\frac{1}{2}$ inches, a considerable proportion are below the size of maturity, but the percentage of the immature, by weight, of the total number of marketable witches is only about 15.

From the large size at which the cod first attains maturity, the proportion of the immature that are marketable is very considerable. Among boxed codlings one often finds a few which are over the biological size at maturity, and measuring as much as 28 inches, the selection as cod or codling on the part of the men on board the trawlers often depending on the meagre or fat condition of the fish, as well as on its length. Of all the cod and codling landed about 30 per cent., by weight, are below the biological size of maturity.

With haddocks and whittings it is very different, since the marketable size approximates to the size at which the fishes first become mature. The calculations in regard to haddocks show that the proportion of the marketable which are immature is very small, amounting to only about 1 per cent. of the total quantity landed. This is much under what one might expect from the statements made as to the large quantities of undersized haddocks sometimes landed, but it is the result of careful observations on a large number of fishes, both in regard to size and weight. All the medium and large haddocks, or firsts and seconds, landed are above the mature size, and the great majority also of the small haddocks, or thirds.

With the whiting the proportion of the immature among marketable fishes is still less, and the quantity of small, or second class, whittings brought to market by trawlers is inconsiderable, while the proportion among those which are under the biological size of maturity is also fractional. It may be said that practically all the whittings marketed by trawlers are of adult size.

It must be borne in mind in connection with this subject that the limit taken is a biological one, having reference, not to the size of the fish from the market point of view, but with reference to reproduction.

With regard to the numbers, as apart from the weight, the calculations show that, taking the mean of several years, the following represents approximately the total numbers of the fish of the kinds named which are brought to Aberdeen market:—Cod, including codling, 4,575,000; haddocks, 110,000,000; whittings, 15,000,000; plaice, 2,400,000; lemon dabs, 1,600,000; witches, 3,900,000; and dabs, 260,000.

INVESTIGATIONS IN THE MORAY FIRTH AND ABERDEEN BAY.

I.

The first of the series of investigations was made in the Moray Firth in February, the steam trawler employed being the "Ben Edra," the trip extending from the 7th to the 13th; nineteen hauls of the net were

recorded. The places visited were Burghead Bay, where most of the hauls were taken, off Cromarty, the Dornoch Firth, and, on the 13th, Aberdeen Bay. The quantity of fish caught was not very great, haddocks particularly being comparatively scarce.

The first haul was made off Burghead Bay, about four miles N.N.W. of Burghead light, in from seventeen to twenty fathoms, and it lasted for four hours and fifteen minutes. The aggregate number of fishes caught was only 228, of which 173 were marketable and fifty-five unmarketable. They included only five haddocks, all marketable, eight cod, fifty plaice, and ninety-four witches, all marketable but eight. The next drag was a little more productive, 692 fishes being caught in the four hours it lasted. Of these 463 were marketable and 229 unmarketable. They included forty-two haddocks, all marketable, fourteen cod, a halibut, three brill, one turbot, 128 plaice, and 191 witches, as well as fourteen lemon dabs, two cat-fish, and nine skates. Other six hauls were made in the same locality, but in rather deeper water, and they were somewhat more productive. The first of these was in from eighteen to twenty-five fathoms, Burghead light bearing from four to five miles S.S.E., and it lasted for four hours and five minutes. The number of fishes obtained was 725, of which 476 were marketable and 249 unmarketable. The former included eighty-eight haddocks, twenty-three cod, fifty-five codling, twenty-one plaice, thirty-eight lemon dabs, and 197 witches, as well as a few cat-fish and skates. The next haul, a little further off in somewhat deeper water—from twenty to thirty fathoms—lasted for four hours and twenty minutes, the aggregate catch being larger, namely, 1029 fishes, of which, however, a larger proportion were unmarketable. The marketable fishes numbered 586, the increase being chiefly in cod, plaice, and witches. The unmarketable consisted of whittings, common and long rough dabs, and herrings, of which seventy-four were taken, showing that a considerable shoal was present on the ground.

The other hauls in this locality were rather less productive, and they were all characterised by the presence of cod, plaice, and especially witches, and the comparative scarcity of haddocks, particularly small haddocks.

In the following Table are given the numbers of the various species of fishes taken in this locality, the marketable being distinguished from the unmarketable. One of the hauls in the deeper water in which the net got fouled is omitted.

	Plaice.	Common Dab.	Witch.	Flounder.	Lemon Dab.	Halibut.	Turbot.	Brill.
I.	495	125	1,699	.	73	1	1	5
II.	.	861	189	.	.	.	.	.
Total	495	986	1,888	.	73	1	1	5

	Long Rough Dab.	Cod.	Codling.	Haddock.	Whiting.	Coal-fish.	Ling.
I.	.	154	117	393	49	20	3
II.	653	.	11	11	150	1	.
Total	653	154	128	404	199	21	3

[Continued.]

	Cat-fish.	Gurnard.	Grey Skate.	Thorn-back.	Starry Ray.	Angler.
I.	4	.	.	14	11	105
II.	.	1	6	2	9	202
Total	4	1	6	16	20	307

There were also taken in these hauls one dragonet, seventy-seven herrings, and two red gurnards. The aggregate number of fishes taken in the seven hauls, the time of actual fishing being thirty hours, was 5445; the average number caught per hour was thus 181.5. The marketable fishes numbered 3269, with an average per hour of 109.0, and the unmarketable 2176, with an average of 72.5. The fish caught in largest numbers was the witch, viz. 1888, the average per hour's fishing being 62.9.

The next few hauls were taken in the same locality but further to the west towards Cromarty, in water from twenty-five to thirty fathoms deep, and on a muddy bottom. In the first of these 1840 fishes were procured, 1125 being marketable. More than half of these were witches, viz. 826, and haddocks were also more abundant than in the previous hauls, thornbacks and starry rays being also more numerous. The same features characterised the remainder of the hauls here, and a considerable number of cod were obtained.

The next drag was for four hours and fifteen minutes, but the net was badly torn, and the catch amounted to only 355 fishes, of which 208 were marketable. The succeeding two hauls were more productive, the number of fishes taken in one of them being 1160, and in the other 2117, the marketable and unmarketable numbering respectively 688 and 1158, witches being in each case the most abundant.

Other two hauls were made a little closer in to Burghead Bay, 1515 and 2009 fishes being obtained, the majority again consisting of witches. Altogether in this locality fourteen drags were taken. In one of these the net was fouled and in another it was badly torn, and the results from these hauls may be excluded. The total duration of the actual fishing of the remaining twelve drags was fifty-two hours, and the aggregate number of fishes taken was 14,072, or an average of 270.6 per hour's fishing; the marketable fishes numbered 7815, or an average of 150.3 per hour, and the unmarketable 6257, the average being 270.6. In the total were included 11,600 flat-fishes, 5992 being marketable and 5608 unmarketable. The most common was the witch, of which 5819 were caught (4987 marketable); the common dabs numbered 2991 (all unmarketable but 203), and there were 1988 long rough dabs. The quantity of plaice taken was moderate, viz. 707, and all were marketable; only eighty-seven lemon dabs were caught, and all these were also taken to market. One black or common sole was obtained, a fish which is very rare on the east coast. Haddocks and whittings were poorly represented, 933 of the former and 263 of the latter being the whole number. Only eleven of the haddocks were too small to be taken to market—a great contrast to what usually obtains in these waters. The cod numbered 286, and the marketable codlings 208; there were also twenty-five codlings too small to be marketable. Among 211 skates and rays were six grey skates, seventy-six thornbacks, 124 starry rays and five

sandy rays. The number of anglers caught was exceptionally large, being 431—150 of them being taken to market. Eighty-three herrings were taken, most of them in one haul, and also twelve sprats.

During most of the time of fishing at Burghead and between it and Cromarty the wind had been blowing with fair strength, although variable in direction. On the 10th it increased in force, and a shift was made to the Dornoch Firth, where four hauls were made in from about six to twelve fathoms. The quantity of fish caught was small, the total in each of three of them being only a little over four hundred of all kinds; in one it amounted to 710. Few haddocks, cod, or whiting were obtained, the bulk of the catch, such as it was, consisting of plaice. A considerable number of flounders were taken, nearly all of large size and engaged in spawning, the four hauls yielding 215.

The total number of fishes got in the four drags in the Dornoch Firth—the actual time of fishing being seventeen hours and ten minutes—was 2027, which represents an average per hour of 118·0. The marketable amounted to 1476, or an average of 86·0 per hour, and the unmarketable 551, or an average of 32·1 per hour. The flat-fishes greatly exceeded the round-fishes in number, there being 1798 of them and only 203 of the latter. Plaice were the most abundant, and after them common dabs. Only 102 haddocks were got, none of them unmarketable, and six whittings, all of which, except one, were unmarketable. The paucity of small haddocks during the whole period of fishing on this occasion is noteworthy.

Only one recorded haul in Aberdeen Bay was made on this trip, and the number of fishes taken was still less than in the Moray Firth. The haul lasted for four hours, and 155 fishes were caught, of which only thirty-five were marketable. These comprised one cod, thirteen codling, fifteen haddocks, three plaice, two lemon dabs, and one flounder, the unmarketable consisting chiefly of whittings and common dabs.

The aggregate total of fishes taken and recorded in the seventeen hauls in February was 16,268, of which 9340 were marketable and 6298 unmarketable. The total of flat-fishes was 13,455, and of round fishes 2016.

The quantity of fish landed at the market by the vessel, as recorded by the Fishery Officer, amounted to 47½ cwts., as follows:—

Cod.	Codling.	Ling.	Coal-fish.	Haddock.	Whiting.	Turbot.	Brill.	Lemon Dab.
7½	2	½	6	2½	½	½	½	½
Plaice.	Dabs.	Witches.	Cat-fish.	Flounder.	Angler.	Skate.		
14	½	6½	1½	1	2	2		

II.

The next series of trawlings was made in March on board the "Devanha," the catches being again recorded by Mr. James Ingram, jun. In all, twenty-two recorded hauls were made, three in Aberdeen Bay on the 16th, three in Burghead Bay on the 17th and 18th, four in the Dornoch Firth, five on Smith Bank off the coast of Caithness, four off Lossiemouth on the 20th, and three off Tarbet Ness on the 21st and 22nd.

In Aberdeen Bay there was a heavy sea, with a S.S.E. wind, and the catches were poor. The first haul here, in from thirteen to nineteen fathoms off Newburgh, lasted for four hours, and 514 fishes were captured, 478 being marketable and thirty-six unmarketable. They included 123 cod and 195 marketable codling, as well as 184 plaice—

all but twenty-eight marketable ; but only four haddocks were taken. The second drag in the same locality, and lasting for four hours and twenty minutes, yielded only 205 fishes, of which 121 were marketable and eighty-four unmarketable. In this haul only eight cod and four codling were taken, but there were ninety-two haddocks—all but eight marketable ; the plaice numbered twenty-two, and there were a number of small skates.

A third drag was made off Newburgh to Donmouth for four hours and five minutes, in from eight to sixteen fathoms, and the catch amounted to 375 fishes, 269 of which were marketable and 106 unmarketable. There were included in it forty-seven cod and 126 marketable codlings, a coal-fish, 145 plaice (ninety-two marketable), as well as a number of unmarketable dabs, flounders, and skates. Only three haddocks were taken.

In the three drags in Aberdeen Bay, the time of the fishing being twelve hours and twenty-five minutes, only 1094 fishes were caught, the average per hour's fishing being 88·1. The marketable numbered 868, with an average number per hour of 69·9, and the unmarketable 226, with an average of 18·2. The total number of haddocks caught was ninety-nine, and of whittings, seven. The following Table gives the particulars of the marketable and unmarketable :—

	Plaice.	Common Dab.	Flounder.	Witch.	Lemon Dab.	Cod.	Codling.
I.	268	.	.	.	4	178	325
II.	83	33	14	4	.	.	.
Total	351	33	14	4	4	178	325

	Haddock.	Whiting.	Coal-fish.	Gurnard.	Grey Skate.	Thorn-back.	Starry Ray.
I.	91	.	2	.	.	.	.
II.	8	7	.	1	17	57	1
Total	99	7	2	1	17	57	1

A lumpsucker was also taken in one of the hauls. These fish are occasionally caught in the trawl net near shore in spring, during their sawning time.

The vessel then steamed to the Moray Firth, visiting first the south coast.

At Burghead Bay the catches were not very productive, comparatively few marketable fishes being got except plaice. The first drag, which lasted for three hours and fifty minutes, in from seven to twelve fathoms, yielded a total of 652 fishes, 439 being marketable and 213 unmarketable. The former comprised four cod, three codling, only two haddocks, no whittings, one turbot, eleven brill, 329 plaice, seventy common dabs, fourteen flounders, three cat-fishes, and two anglers—the unmarketable consisting almost entirely of dabs. In the second haul, which lasted for four hours and fifteen minutes, 705 fishes were got, of which 316 were marketable, the majority consisting of plaice. Twenty-eight skates and rays were taken, ten being marketable, and three herrings.

The third drag was more productive, 948 fishes being taken—607 marketable and 341 unmarketable; it lasted for four hours. The bulk of the catch was composed of plaice and common dabs, 469 of the former and 398 of the latter; all the plaice except forty-three were marketable, and 137 of the dabs.

Altogether the number of fishes obtained in the three drags in Burghead Bay aggregated, for the twelve hours and five minutes of actual fishing, 2305, of which 1362 were marketable and 943 unmarketable. The flat-fishes greatly preponderated, 2087 being caught, against only 121 round-fishes. Among the flat-fishes 1314 were taken to market and 773 thrown overboard, while only thirty-one of the round-fishes were marketable, the marketable haddocks numbering two, and there were no marketable whittings. The plaice caught numbered 1024, all but forty-three being taken to market. The productiveness of the grounds in Burghead Bay on this occasion was shown by the number taken per hour's actual fishing, which was 190·8 for all kinds of fish—112·7 for the marketable and 78·1 for the unmarketable. The average for the marketable plaice was 81·2 per hour's fishing.

The particulars of the marketable and unmarketable fishes are as follows:—

	Plaice.	Common Dab.	Flounder.	Lemon Dab.	Turbot.	Brill.	Cod.	Codling.
I.	981	263	39	10	1	20	7	13
II.	43	729	.	.	.	1	.	4
Total	1,024	992	39	10	1	21	7	17
	Had-dock.	Whiting.	Cat-fish.	Gurnard.	Angler.	Thorn-back.	Starry Ray.	Sandy Ray.
I.	2	.	9	.	2	7	5	3
II.	45	40	.	1	37	16	14	5
Total	47	40	9	1	39	23	19	8

There were also taken in these hauls seven herrings and one lump-sucker.

After leaving Burghead Bay the vessel steamed to the Dornoch Firth, where four hauls were made in the usual locality, in sweeps around the bay opposite Dunrobin, Golspie, and Embo, the depth of water being from about eight to sixteen fathoms. In the first haul, which lasted for four hours and five minutes, 999 fishes were taken, of which 822 were marketable and 177 unmarketable. The marketable fishes comprised twenty-four cod, 369 plaice, seventy-one common dabs, 317 flounders, as well as ten cat-fish, three lemon dabs, and eighteen skates and rays. Round-fishes continued to be very scarce, only two haddocks and a single whiting being caught. The second drag was a very poor one, only 229 fishes being obtained, of which 148 were marketable. There were fifty-seven plaice, sixteen cod, twelve common dabs, and fifty-two flounders. Three herrings and twenty-two sprats were also taken. The next haul was better, a hundred cod and 110 marketable codling, as well

as 174 plaice, eleven lemon dabs, and a number of common dabs and flounders, being caught. In the fourth drag the net got badly split, and the catch was small, amounting to only 160 fishes, 111 being marketable. It however included thirty-eight cod and forty-seven marketable plaice.

Omitting this imperfect haul, the total number of fishes taken in the other three drags in the Dornoch Firth was 2066, of which 1470 were marketable and 596 unmarketable. The duration of the fishing in these drags was twelve hours and fifteen minutes, and the averages per hour's fishing were therefore as follows:—120·0 for the marketable, 48·7 for the unmarketable, and 168·7 for both included. The average for plaice was 49·0 per hour. The three hauls yielded 140 cod, but only seven haddocks and a single whiting, all marketable. The absence of small haddocks and whittings both here and at Burghead Bay was remarkable, and formed a striking contrast to what obtained later in the year.

The numbers of marketable and unmarketable fishes caught in the three drags in the Dornoch Firth are as follows:—

	Plaice.	Common Dab.	Flounder.	Lemon Dab.	Brill.	Cod.	Codling.	Haddock.
I.	600	128	420	16	2	140	115	7
II.	8	509	48	.	.	.	.	.
Total	608	637	468	16	2	140	115	7

	Whiting.	Cat-fish.	Angler.	Grey Skate.	Thorn-back.	Starry Ray.	Sandy Ray.
I.	1	14	.	1	.	3	1
II.	.	.	2	.	22	2	.
Total	1	14	2	1	22	5	1

There were also caught three herrings, twenty-two sprats, and two lumpsuckers.

On leaving the Dornoch Firth the vessel ran to Smith Bank, where five hauls were made on the western edge in from about nineteen to twenty-eight fathoms of water, and here much better results were obtained than in the localities above described. The first haul, which lasted for four hours, yielded 726 fishes, of which 262 were marketable and 464 unmarketable. The catch included eleven cod, a halibut, forty plaice, a few lemon dabs and witches, and also 223 haddocks, in the latter respect thus differing from the catches in the Dornoch Firth and Burghead Bay. Eighty-two of the haddocks were too small to be marketable. There were also 117 gurnards, a fish more sparingly represented in the previous localities—at this season it is only found in any number in the deeper waters offshore. The second drag was better than the first, 1016 fishes being caught, of which 670 were marketable. They included thirty cod 574 haddocks, sixty-nine plaice, fifty-eight lemon dabs, and seven cat-fish. Seventy-five of the haddocks were too small to be marketable.

The third haul produced 1934 fishes, 648 being marketable and 1286 unmarketable. On this occasion haddocks were well represented, 1379 being taken; no less than 973 of these were too small to be marketable.

The catch included twenty-eight cod, ninety plaice, 111 lemon dabs, three cat-fish, and a few other kinds. The fourth and fifth hauls were not quite so good as regards the number of fish caught. In the first of them the total was 901, of which only 166 were marketable, and these included sixty-two cod, forty-four plaice, fifty-two lemon dabs, and five cat-fish. There were 333 haddocks, all too small to be marketable, and 126 whittings, of which only one was marketable. The number of fishes in the last haul was still less, viz. 664, and all except 100 were unmarketable. Those taken to market comprised twenty-three cod, fifty-four plaice, two coal-fish, eleven lemon dabs, and a few others. The number of haddocks caught was 127, and of whittings 216, but all the latter and all except three of the haddocks were unmarketable.

Altogether in the five hauls in this locality, the time of actual fishing being twenty hours and twenty-five minutes, 5241 fishes were taken, the average per hour's fishing being 256·7. The proportion of marketable was, however, not large, owing to the numbers of small haddocks and dabs ; the number was 1846, the average per hour being 90·4, while there were 3395 unmarketable, giving a ratio of 166·2 per hour.

The aggregate number of flat-fishes in the five drags was 1779, 569 being marketable and 1208 (chiefly common and long rough dabs) unmarketable. Plaice were most numerous, 297 being taken, and lemon dabs next, of which 249 were caught, all but ten marketable. The aggregate of round-fishes was 3395, there being 1268 marketable and 2127 unmarketable. The number of haddocks was 2636, and 1049 of them were marketable and 1587 too small to be taken to market—a considerable proportion. The average number of haddocks taken per hour's fishing was 129·1.

The particulars as regards the marketable and unmarketable of each kind are given in the following Table :—

	Plaice.	Com. Dab.	Floun- der.	Witch.	Lemon Dab.	Halibut.	Long Rough Dab.	Brill.	Megrim
I.	297	3	2	22	239	2	.	1	3
II.	.	826	.	44	10	.	328	.	.
Total	297	829	2	66	249	2	328	1	3

	Cod.	Codling.	Had- dock.	Whiting.	Coal- fish.	Hake.	Cat- fish.	Gur- nard.	Grey Skate.	Thorn- back.
I.	154	14	1,049	30	4	.	17	.	8	1
II.	.	22	1,587	368	.	1	.	149	6	26
Total	154	36	2,636	398	4	1	17	149	14	27

There were also caught in these hauls eighteen (unmarketed) anglers, one dragonet, and nine red gurnards.

The next place examined was the grounds off Lossiemouth, where four drags were made on the 20th, in from about seven to fourteen fathoms of water. In two of them the net was badly torn, and the catches in these cases was small, and may be neglected. In the first of the others the total number of fishes caught in the four hours during which the drag

lasted amounted to 785, and of these 556 were marketable and 229 unmarketable. Very few haddocks were obtained, the total being three, all marketable; the chief fishes were cod, of which fifty were got, codling, plaice, and flounders. In the other haul 690 fishes were obtained, 570 being marketable. On this occasion also the marketable fishes consisted for the most part of cod, codling, plaice, and flounders, while only six haddocks were taken.

The aggregate for the two hauls here, the actual fishing lasting eight hours and fifteen minutes, was 1474, or an average per hour of 178·7. The marketable fishes numbered 1126, an average of 136·5 per hour, and the unmarketable 348, giving an average of 42·2. The flat-fishes greatly preponderated, 1134, or an average of 137·4, being caught, as compared with 327 round-fishes, with an average of 39·6. All the round-fishes were marketable, and they comprised the large number of 127 cod, 172 codling, five coal-fish, and twelve cat-fish, but only nine haddocks and two whittings. The flat-fishes included 524 plaice, all marketable except nine (the average of the former being 62·4), 350 common dabs, and 243 flounders.

Although the catches here were good, the fishing was carried on at some expense of gear, and a shift was made to the north-east, off Tarbet Ness, where three drags were taken in from twenty to twenty-six fathoms of water. In the first, which occupied four hours and thirty-five minutes, only 222 fishes were taken, 174 marketable, but the net was slightly split. In the next haul 449 were caught, of which 130 were marketable, and in the third 259, the marketable numbering 161. The chief fish taken in this locality was cod, 142 being obtained.

Taking the two perfect hauls, the time of actual fishing being eight hours and ten minutes, the number of fishes secured was 708, the average per hour being 86·6. The number of marketable was 291, with an average of only 35·6, and the unmarketable 417, with an average of 51·0. The total included 137 plaice, 124 cod, 201 haddocks, of which only sixteen were marketable, sixteen whittings, all unmarketable, and a few others.

The quantity of fish landed from this trip amounted to 140½ cwts, as follows :—

Cod. 81	Codling. 5½	Ling. 1½	Coal-fish. 2	Haddock. 3½	Turbot. ½	Halibut. ½	Brill. ½
Lemon Dab. 2½	Plaice. 28½	Dabs. 1½	Megrim. ½	Flounder. 4½	Cat-fish. 5	Skates. 5	

III.

From the 8th to the 13th of June another series of trawlings was made on board the "Drumblair," the places visited being Burghead Bay, the grounds off Lossiemouth, the Dornoch Firth, the ground off Lybster, Smith Bank, and Aberdeen Bay, twenty-two hauls being recorded.

The fishing in Burghead Bay, where three drags were made on the 8th and 9th, was very poor, the total number of fish taken being only 560, of which 203 were marketable, the duration of the fishing being six hours and forty minutes. In one of the hauls the net was slightly torn, and in the other two, lasting for four hours and forty minutes, 390 were caught, 125 of them being marketable. The average per hour at this time in Burghead Bay was 84·1, the average for the marketable being only 30·5. The catch consisted chiefly of plaice; only one cod, two codlings, a single haddock, and three whittings were caught. An explana-

tion of the poor takes was probably the very large quantity of weed which was found in the net, which was with difficulty cleansed of it, experience showing that under such circumstances fish are usually scarce.

On leaving Burghead Bay the vessel proceeded to the ground off Lossiemouth, where a haul was made in from eleven to fourteen fathoms, about three miles off. The net was hauled in fifty minutes, and it contained 278 fishes, of which only forty-one were marketable, viz. forty plaice and one black or common sole. The unmarketable fishes numbered 237, and consisted of common dabs, small plaice, and gurnards, of which there were 110. The weather both here and at Burghead Bay was quite calm, the sea smooth, and there was a slight fog.

The vessel then steamed to the Dornoch Firth, where a number of drags were taken. In the first, which lasted for only twenty-eight minutes, the net having caught on something on the bottom, ninety-five fishes were taken, of which forty-one were marketable and fifty-four unmarketable. They consisted mostly of plaice and common dabs; only one haddock was obtained, and there were no whittings. For the time the net was fishing the catch was fairly good, and a "dan" was put down and a few of the succeeding hauls were made around it. In the first of these, in from five to eleven fathoms, and in two hours and forty-two minutes actual fishing, a large bag of fish was secured. The total number of fishes was 4928, of which 1555 were marketable and 3373 unmarketable. With the exception of fifty gurnards and twenty-four thornbacks, they were all flat-fishes and nearly all plaice. These numbered no less than 4638, of which 1525 were marketable and 3113 unmarketable; the former consisted of eleven "large," 205 "mediums," 370 "small," and 939 "fourths." The small unmarketable plaice measured from three and three-quarter inches up to ten inches in length. The catch also included four brill and six flounders.

In the next recorded haul, on the same ground and lasting for four hours, 4859 fishes were taken, of which 1318 were marketable and 3541 unmarketable. The great bulk again consisted of plaice, which numbered 4517, and of these 1211 were marketable and 3306 unmarketable. The other marketable fishes included one turbot, one brill, eighty-five common dabs, one lemon dab, and nineteen thornbacks. The small "offal" plaice were of the same sizes as in the former haul, and their great abundance showed how destructive the otter-trawl may be on such shallow-water grounds in certain cases. In the two hauls forty-three thornbacks were got, and the males greatly preponderated. In fifty-six examined from these and other catches, there were fifty-one males and only five females—a proportion the reverse of what usually obtains.* The larger and medium-sized gurnards were spawning, and they were found to be feeding on shore-crabs.

Owing to the quantity of small plaice taken, it was decided to shift a little further out so as to avoid the shallow water, and the result was immediately apparent. In the first haul made here, in from nine to thirteen fathoms, the "bag" was not so large, but the fish were of better size. The haul lasted for four hours and two minutes, and the fishes caught numbered 1144, of which 432 were marketable and 712 unmarketable. The former included 412 plaice, of a total of 1105, the large numbering twenty-eight, the medium fifty-eight, the small 110, and the fourths 216. There were also two cod, ten common dabs, two flounders, one cat-fish, and five thornbacks. The fourth class of marketable plaice consisted of fish measuring from 23 centimetres (nine inches) to a little over 31 centimetres (twelve and a half inches), and the unmarketable from 19·8 cm.

* *Twenty-first Annual Report*, Part III., p. 280.

(seven and three-quarter inches) to about 23·5 cm., or nine and a quarter inches ; a few were a little larger. The selection of the various classes by the men, being solely by the eye, is never perfect, one class always overlapping another more or less.

A number of other hauls were made on this ground with the same general results, the marketable fishes consisting of plaice and scarcely anything else, round-fishes, with the exception of gurnards, being almost absent. During the time in the Dornoch Firth the weather was very favourable for fishing operations on the whole, though on the 10th there was some wind from the east, which made the sea a little choppy, causing the vessel to roll.

In the ten recorded hauls in the somewhat deeper water, from eight to thirteen fathoms and mostly from eight to eleven, the time of actual fishing being thirty-eight hours and thirty-two minutes, the aggregate number of fishes captured was 7613, of which 3565 were marketable and 4046 unmarketable. They consisted mostly of flat-fishes, and chiefly of plaice, the former numbering 7316, and the round-fishes, nearly all gurnards, only 279. The average per hour's fishing was 92·5 for the marketable, and 105·0 for the unmarketable, the general average for both combined being 197·5. Only five cod, two (unmarketable) codlings, thirty-two haddocks, all marketable, were taken, and not a single whiting. The plaice numbered 6680, of which 3450 were marketable and 3230 unmarketable, the respective averages per hour's fishing being 89·5 and 83·8 for the marketable and unmarketable, and 173·3 for both together.

In the two first hauls in the somewhat shallower water above described a greater number of fishes were captured in the six hours and forty-two hours of fishing, viz. 9787, the average per hour being 1460·7 ; the marketable numbered 2873, with an average of 428·7, and the unmarketable 6914, with an average of 1032·0. The number of plaice in these two hauls was 9155, the average per hour being 1366·4 ; the marketable amounted to 2736, with an average of 408·4, and the unmarketable to 6419, with an average of 958·0. These numbers are very rarely reached.

The number of marketable and unmarketable fishes taken in the twelve hauls was as follows:—

	Plaice.	Com. Dab.	Floun- der.	Brill.	Turbot.	Lemon Dab.	Cod.	Codling.
I.	6,186	141	11	7	1	1	5	.
II.	9,649	963	8	.	.	.	.	2
Total	15,835	1,104	14	7	1	1	5	2

	Haddock.	Hake.	Cat-fish.	Gurnard.	Anglor.	Thorn- back.	Sprat.
I	32	1	5	.	.	50	.
II.	.	.	.	234	8	7	1
Total	32	1	5	234	8	57	1

It is of interest to contrast the proportions in which the plaice of different sizes were caught in the two hauls in the shallower water and in

the ten in a little deeper water on this occasion ; and in the appended Table I give the percentage of each size to the total, and the average number taken in each hour's fishing in the two cases respectively. The two hauls are indicated by A and the ten by B.

		Large.	Medium.	Small or Thirds.	Fourths.	Unmarket- able.
A	No.	27	329	681	1,699	6,419
B	No.	174	775	1,179	1,322	3,230
A	Percent- age.	0·29	3·59	7·43	18·55	70·11
B		2·60	11·60	17·65	19·80	48·3
A	No. per Hour's Fishing.	4·0	49·1	101·6	253·6	958·0
B		4·5	20·1	30·6	34·3	83·8

It will be seen how much greater the proportion of small plaice, under about ten inches, is in the former case than in the latter. The actual abundance on the ground, as shown by the average per shot, indicates that while the large plaice were nearly equally distributed, the medium plaice, and still more markedly those still smaller, were far more numerous in the shallower water. Nevertheless it will be observed that the largest average in each case is for the unmarketable fish, that is, under about nine and a half or ten inches.

Two hauls with the small-meshed net around the cod-end were made in the Dornoch Firth. In the first, which was for an hour and twenty-eight minutes, it was found on getting the trawl up that the fine net had been holed. The total number of fishes taken was 143, belonging to eleven species, as follows:—Plaice 55, common dab 38, lemon dab 2, little or yellow sole 3, cod 10, haddock 1, gurnard 14, cat-fish 1, sand-eel 16, goby 1, gemmeous dragonet 2. In the second haul, which lasted for an hour, the catch was also very small, viz. 170 fishes, belonging to five species, viz.—plaice 103, common dab, 57, gurnard 7, sand-eel, 1, angler 2.

The next place where fishing was carried on was off Lybster on the coast of Caithness, where a drag for two hours in twenty-three fathoms gave 584 fishes, of which 383 were marketable and 201 unmarketable. The catch comprised six marketable plaice, forty-six marketable lemon dabs, and forty common dabs, as well as 410 haddocks, 308 of them being marketable, two cod, and forty-four whittings, twenty-five of which were too small to be marketable.

Smith Bank was then visited, and a haul there, in from nineteen to twenty-two fathoms, for two hours and five minutes, gave a total of 773 fishes, 378 being marketable. The flat-fishes consisted of two turbot, 220 common dabs, and twenty-nine lemon dabs, all but seven of them marketable; there were also taken 481 haddocks, 316 marketable, one cod and twelve marketable codlings, as well as two cat-fish and twenty-three gurnards.

After leaving the Moray Firth five hauls were made in Aberdeen Bay, with very good results. The first was in from eight to ten fathoms off the Black Dog, and it lasted for four hours. The number of fishes taken was 1749, of which 1384 were marketable and 365 unmarketable, the bulk of the catch consisting of plaice and haddocks. Of 917 haddocks caught, 707 were marketable and 210 unmarketable; all the former

were "thirds" or small. The plaice totalled 597, all but twenty being marketable, and of these twenty-five were large, 363 mediums, and 189 small. There were also one cod, three marketable codlings and fourteen unmarketable, forty small whittings, 150 dabs, twenty-five gurnards, and two anglers.

The next haul in the same place, and also lasting for four hours, gave almost exactly the same numbers, the total being 1745, the marketable 1312 and the unmarketable 433. The haddocks numbered 1013, all being small and 250 of them unmarketable, while of the 507 plaice, all of which were marketable, fifteen were large, 162 medium, and 330 small; there were no "fourths," a still smaller class, as in the Moray Firth.

In these two drags at this place, the duration of fishing being eight hours, 3494 fishes were captured, the average per hour being 436.6. The marketable, numbering 2696, gave an average of 337.0, and the unmarketable, of which there were 798, an average of 99.6.

Three other hauls were made in from twelve to fifteen fathoms, off Slains Castle, with even better results. Only one was completely recorded; it lasted for four hours, and 2068 fishes were taken, 1855 marketable and 213 unmarketable. The number of haddocks was 1797, all but 109 marketable; there were fewer plaice, viz. 160, all marketable, and they comprised sixty mediums and one hundred small. The other marketable fishes were two turbot and five brill. In the next haul, for three hours, 4283 marketable fishes were secured; the unmarketable were not counted, but they consisted of six basketfuls, mostly of small haddocks. The haddocks enumerated amounted to 4126, of which 303 were mediums, 3193, smalls and 630 fourths, or very small. There were also eighty-seven plaice, all marketable, and seventy marketable common dabs. The last drag, for four hours, yielded 1985 marketable fishes, the haddocks numbering 1871 and the plaice 107; all the haddocks were thirds and fourths. The offal was not noted.

The following are the particulars of each class of fish taken in the three completely recorded drags in Aberdeen Bay:—

	Plaice.	Common Dab.	Turbot.	Brill.	Cod.	Cod-ling.	Had-dock.	Whit-ing.	Gur-nard	Ang-ler.
I.	1,244	94	2	7	1	3	3,158	40	-	2
II.	20	263	-	-	-	39	569	56	61	3
Total	1,264	357	2	7	1	42	3,727	96	61	5

The quantity of fish landed at the market, as the result of this trip, as recorded by the Fishery Officer, was 81 cwts., as follows:—

Cod.	Codling.	Coal-fish.	Hake.	Haddock.	Turbot.
$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{10}$	$\frac{1}{2}$	4	$\frac{1}{2}$
Brill.	Lemon Dab.	Plaice.	Cat-fish.	Flounder.	Skates.
$\frac{1}{2}$	$\frac{1}{8}$	63 $\frac{1}{2}$	1 $\frac{1}{2}$	$\frac{1}{2}$	9

IV.

In October another series of trawlings was made, by means of the steam-trawler "Star of the North," the grounds visited being Aberdeen Bay, Burghead Bay, the Dornoch Firth, off Lybster, and Smith Bank.

In Aberdeen Bay five hauls were made on the 16th and 17th of the month, with fair results, a strong breeze blowing from the S.W., while the sea was rough. The first was off Black Dog in from eight to twelve fathoms, and it lasted four hours. The catch amounted to 1978 fishes, of which 1938 were marketable, most consisting of haddocks. Of these 1517 were caught, all marketable, the majority being "large" or "firsts," viz. 749. Thirteen cod and 121 codlings, of which 118 were marketable, were included in the catch, as well as 264 whittings, twenty-two plaice, one lemon dab, and twenty-eight common dabs. The next drag in the same locality, and in from nine to twelve fathoms, gave almost the same result, viz. a total of 1964, of which 1889 were marketable. The number of haddocks was 1099, all marketable, there being 395 large, 164 medium, and 540 thirds. There were also four cod and 282 codlings, all but nine marketable, 275 whittings, ten brill, 194 plaice, twelve lemon dabs, and seventy-three common dabs. A third haul for four hours in the same locality gave 1287 fishes, 1216 of which were marketable, the bulk of the catch consisting of large and medium haddocks, cod, codlings, and plaice.

The fourth drag was made in from twelve to twenty fathoms, from the same place towards Cruden Skerries, and lasted for three hours and a quarter. The catch consisted of 1685 fishes, 1634 being marketable. The number of haddocks was 790, of which 237 were large, 156 mediums, and 397 thirds. Besides nine cod, 387 codlings were taken, all but five marketable, 228 whittings, 204 plaice, some dabs and rays. The fifth haul was made from the Skerries towards Aberdeen and lasted for an hour. The catch amounted to 208 fishes, chiefly haddocks, whittings, and plaice; it was made with the small-meshed net around the cod-end.

The three hauls in from eight to twelve fathoms, the time of actual fishing being eleven hours and fifty minutes, yielded a total of 5229 fishes, the rate per hour being 442·0. The marketable numbered 5043, with an average per hour of 426·3, and the unmarketable 186, with an average of 15·7. The aggregate of haddocks was 3281, with an average per hour of 277·3. A feature was the large number of marketable codlings, of which 570 were taken in three hauls.

The particulars of the catches of the first four drags in Aberdeen Bay are these:—

	Plaice.	Common Dab.	Lemon Dab.	Turbot.	Brill.	Cod.	Codling.
I.	615	71	30	3	23	52	952
II.	-	126	-	-	-	-	28
Total	615	197	30	3	23	52	980
	Haddock.	Whiting.	Gurnard.	Angler.	Grey Skate.	Thorn-back.	Starry Ray.
I.	4,071	830	-	1	16	8	5
II.	-	49	21	2	8	2	6
Total	4,071	879	21	3	19	10	11

In the haul with the small-meshed net, for an hour, the total number of fishes caught was 384, as follows:—Plaice 42, common dab 26, long rough dab 1, cod 22, haddock 94, whiting 190, sprat 9.

The fishing in the Moray Firth was begun on the 19th, Burghead Bay being first visited ; the weather was calm, and very large quantities of fish were taken. The first haul was in from twelve to twenty fathoms, but mostly in and about ten, and lasted for four hours. The bag of fish was an exceptionally large one, comprising thirty-one and a half baskets of haddocks, mostly small, and six baskets of plaice, as well as other fishes. The total number of the fishes caught was 8382. of which 7286 were marketable and 1096 unmarketable. Among the former were 6439 haddocks and 622 plaice, sixty whittings, a halibut, two brill, thirty witches, twenty common dabs, and ninety-six gurnards. The unmarketable consisted chiefly of common dabs, whittings, and plaice.

The other four hauls at Burghead Bay were made in water from eight to twelve and thirteen fathoms, and they were also good in regard to the result. In the first, lasting for four hours, 3446 fishes were taken, 2581 marketable and 865 unmarketable. The former included 1463 haddocks, 646 plaice, and 255 whittings, and also a turbot, three brill, two witches, and some common dabs and gurnards. The next, also for four hours, produced 2556 fishes, 1596 marketable and 960 unmarketable, haddocks and plaice predominating. In the next haul, also for four hours, 4037 fishes were caught, 3005 of them being marketable and 1032 unmarketable. The catch included 2119 haddocks and 491 plaice.

In the last haul, for one hour, the catch amounted to 912 fishes, 515 being marketable and 397 unmarketable ; most consisted of plaice, haddocks, and common dabs.

The aggregate quantity of fish taken in these five drags, the time of fishing being seventeen hours, was the large one of 19,333 fishes, 14,983 being marketable and 4350 unmarketable. The averages per hour's fishing were 1137·2 for the whole, 881·3 for the marketable, and 255·9 for the unmarketable. The total number of haddocks was 10,910, with an average of 641·8 ; the number of plaice was 2730, the average being 160·6, and the number of common dabs 3618, giving an average per hour of 212·8. There were very few cod or codlings, viz. three of the former and fifty-two of the latter, and 523 gurnards, of which 379 were taken to market. The productiveness of the grounds in Burghead Bay on this occasion very strikingly contrasted with the condition in spring and in June.

The following Table gives the numbers of the marketable and unmarketable fishes taken in the five hauls, the former being distinguished by the figure I., and the latter by II. :—

	Plaice.	Common Dab.	Witch.	Lemon Dab.	Halibut.	Turbot.	Brill.	Angler.
I.	2,622	218	68	6	1	2	5	-
II.	108	3,400	-	-	-	-	-	43
Total	2,730	3,618	68	6	1	2	5	43

	Cod.	Codling.	Haddock.	Whiting.	Hake.	Gurnard.	Thorn-back.
I.	3	49	10,753	865	1	379	11
II.	-	3	157	495	-	144	-
Total	3	52	10,910	1,360	1	523	11

The proportion of the small plaice to those of larger size here was very different to what it was in the Dornoch Firth in June. The unmarketable gave only a ratio of 6·3 per hour, as shown in the appended Table, which also gives the numbers, and the average per hour's fishing, for the various classes of haddocks :—

Plaice.	Large.	Medium.	Small.	Fourths.	Unmarketable.
No. . .	22	677	795	1,128	108
Average per Hour .	1·3	39·8	46·8	66·3	6·3
Haddock.	Large.	Medium.	Small.	Fourths.	Unmarketable.
No. . .	62	521	9,988	182	157
Average per Hour .	3·6	30·6	587·5	10·7	9·2

In one haul, for an hour, in eight to twelve fathoms, with the small-meshed net around the cod-end of the otter-trawl, 997 fishes were obtained, belonging to twelve species, as follows :—

Plaice. 229	Common Dab. 340	Witch. 13	Cod. 21	Haddock. 246	Whiting. 93
Hake. 1	Gurnard. 50	Pogge. 1	Angler. 1	Dragonet. 1	Thornback. 1

The fishing in the Dornoch Firth, which was the next place visited, was fairly good, but not so productive as at Burghead Bay. The first haul was made on the afternoon of the 20th October, off Dunrobin and Golspie, in from eight to fourteen fathoms of water, and lasted for two hours. The number of fishes caught was 793, of which 677 were marketable and 116 unmarketable. They included forty-two cod, thirty-three codlings, all but seven marketable, 592 haddocks, nearly all marketable, twenty-seven whittings, two brill, twenty-two plaice, and one or two others. The weather was fine, a light wind blowing from the south-west. In the next drag in the same locality, and lasting also for two hours, 842 fishes were caught, 771 being marketable. There were only three cod, but the number of haddocks was increased to 652, and of plaice to a hundred. A number of other hauls were made on the same grounds, the best being one of four hours' duration, by which 2486 fishes were taken, 2239 marketable and 247 unmarketable. Only one cod was included in the catch, but there were 1846 haddocks and 345 plaice, as well as some codlings, whittings, lemon dabs, and others. In the next haul the net was split, but the one succeeding it yielded 2223 fishes, 2081 being marketable. The haddocks numbered 1926, and the plaice 133, and there were also five cod, forty-two codlings, and some dabs.

Altogether there were nine recorded drags in this place, and the aggregate of fishes taken was 12,253, 9611 being marketable and 2642 unmarketable. The averages per hour of actual fishing were 331·4 for the marketable, 91·1 for the unmarketable, and 422·5 for both combined. The average per hour for the haddocks was 266·8 and for the plaice 57·0.

In the following Table are given the totals of each kind of fish taken in these nine hauls, the marketable being indicated by I. and the unmarketable by II. :—

	Plaico.	Common Dab.	Witch.	Lemon Dab.	Brill.	Cod.	Codling.
I.	1,552	89	2	23	5	54	138
II.	100	2,099	-	-	-	-	45
Total	1,652	2,188	2	23	5	54	183

	Haddock.	Whiting.	Coal-fish.	Gurnard.	Cat-fish.	Thornback.
I.	7,666	33	-	35	1	12
II.	70	190	2	99	-	-
Total	7,736	223	2	134	1	12

There were also a conger, seven anglers, twenty-two sprats, five picked dog-fishes, an armed-bullhead, a little or yellow sole, and a sting ray (*Trygon*). The proportions of the plaice and haddocks of different sizes is indicated in the following Table:—

		Large.	Medium.	Small.	Fourths.	Unmarketable.
Plaice	No. . .	100	261	438	753	100
	Average per Hour .	3.4	9.0	15.1	26.0	3.4
Haddock	No. . .	1,033	879	5,754	-	70
	Average per Hour .	35.6	30.3	198.4	-	2.4

In a haul for an hour, in from eight to thirteen fathoms, with the small-meshed net around the cod-end, 1522 fishes were captured, belonging to fifteen species, as follows :—

Brill, - - -	1	Coal-fish, - - -	1
Plaice, - - -	364	Gurnard, - - -	35
Lemon Dab, - - -	3	Pogge, - - -	4
Common Dab, - - -	724	Sprat, - - -	43
Little Sole, - - -	8	Sting Ray, - - -	1
Cod, - - -	8	Thornback, - - -	1
Haddock, - - -	95	Piked Dog-fish, - - -	1
Whiting, - - -	233		

After leaving the Dornoch Firth the vessel steamed to the grounds off Lybster, where five hauls were made in twenty-three and twenty-four fathoms of water and good catches of haddocks got. In the first, which was for one hour, 1008 fishes were taken, of which 956 were marketable and fifty-two unmarketable. The haddocks numbered 904, all but four marketable ; there were also fifty-one whittings, fourteen plaice, five lemon

dabs, and thirty common dabs. The next drag, for two hours, yielded 2740 fishes—2674 being marketable and sixty-six unmarketable. The number of haddocks caught was 2463 (twenty basketfuls), all except nine marketable ; there were also 224 whittings and a few flat-fishes. The third haul, for three hours, was scarcely so good, 2810 fishes being taken, of which 2665 were marketable. The catch included 2008 haddocks, nineteen codlings, twenty-six plaice, four lemon dabs, and eighty-six common dabs.

The five drags here—the time of actual fishing being thirteen hours—produced altogether 9992 fishes, or at the rate of 768·6 per hour ; the marketable numbered 9536, the average per hour being 732·5, and the unmarketable 456, with an average per hour of 35·1. The total number of haddocks was 8063, of which only forty-nine were unmarketable, the average per hour's fishing being 620·2. Only 349 flat-fishes were caught in the five hauls, and of these 108 were marketable, consisting of eighty-two plaice and twenty-six lemon dabs ; the unmarketable were 241 common dabs.

The following Table gives the numbers of the marketable and unmarketable fishes respectively :—

	Plaice.	Lemon Dab.	Common Dab.	Cod.	Cod-ling.	Had-dock.	Whit-ing.	Gur-nard.	Thorn-back.	Ang-ler.
I.	82	26	-	25	45	8,014	1,315	27	2	-
II.	-	-	241	-	28	49	121	16	-	1
Total	82	26	241	25	73	8,063	1,436	43	2	1

The haddocks were on the whole of a good class, 2078 being firsts, 1530 mediums, and 4406 thirds, the respective averages per hour's fishing being as follows :—

No.	Firsts.	Seconds.	Thirds.	Fourths.	Unmarketable.
	2,078	1,530	4,406	—	49
Average	159·8	117·7	339·0	—	3·8

Of the eighty-two plaice obtained, seven were large or firsts, sixty-four were mediums, and eleven thirds.

A small-meshed haul was made here for one hour, but the fine net was torn. The number of fishes taken was 1034, as follows :—

Plaice, -	-	-	14	Cod, -	-	-	9
Lemon Dab,	-	-	5	Haddock, -	-	-	906
Common Dab,	-	-	49	Whiting, -	-	-	51

Before leaving the Moray Firth two hauls were made on Smith Bank, on the edge, in about twenty-one and twenty-two fathoms. The first, for an hour, with the small-meshed net attached, yielded 1300 fishes, of which 350 were marketable and 950 unmarketable. The latter chiefly consisted of common dabs and whittings, and the former of haddocks. The total for both nets was 1811 fishes, belonging to twelve species, as follows :—

Plaice, -	-	-	31	Haddock, -	-	-	306
Common Dab,	-	-	962	Whiting, -	-	-	442
Lemon Dab,	-	-	15	Gurnard, -	-	-	15
Long Rough Dab,-	-	-	20	Pogge, -	-	-	4
Little Sole, -	-	-	1	Gobius minutus,	-	-	1
Cod, -	-	-	10	Dragonet, -	-	-	4

The second drag was for three hours and forty minutes, and the number of fishes taken was 1236, 980 being marketable and 256 unmarketable. They included 107 cod, twenty-seven codlings, all marketable, a ling, 796 haddocks, all but ten marketable, thirty-four plaice, all marketable, fifteen lemon dabs, and some whittings and common dabs.

The haddocks were mostly of the third or small class, only thirty being firsts and 110 seconds.

Another haul with the small-meshed net around the cod-end was made at the "witch ground" about twelve miles off Kinnaird Head, the depth being fifty-one fathoms, and the duration of the haul one hour. The total number of fishes taken in both nets was 2187, belonging to eleven species; no witches were captured. The numbers of each kind were as follows:—

Plaice, - - -	3	Whiting, - - -	422
Common Dab, - -	412	Norway Pout, - -	613
Long Rough Dab, -	269	Gurnard, - - -	12
Cod, - - - -	1	<i>Gobius minutus</i> , -	1
Hake, - - - -	6	Angler, - - -	1
Haddock, - - -	447		

The aggregate number of fish taken in twenty-four recorded hauls in this trip in the Moray Firth and Aberdeen Bay—the duration of the actual fishing being seventy-seven hours and forty minutes—was 49,728. Of these, 41,787 were brought to market and 7941 thrown overboard.

The quantity, in cwts., as determined by the Fishery Officer when the fish were landed, was as follows, the total being 271 $\frac{3}{4}$ cwts. :—

Cod.	Codling.	Ling.	Hake.	Haddock.	Whiting.
39 $\frac{1}{2}$	17 $\frac{1}{4}$	$\frac{1}{4}$	$\frac{3}{8}$	143 $\frac{1}{4}$	14 $\frac{1}{4}$
Turbot.	Brill.	Lemon Dab.	Plaice.	Dabs.	Witches.
$\frac{7}{8}$	1	2 $\frac{1}{4}$	44 $\frac{3}{4}$	$\frac{1}{4}$	$\frac{1}{8}$
	Conger.	Skate.	Gurnard.	Angler.	
	$\frac{1}{4}$	3 $\frac{1}{4}$	2	1	

V.

At the end of October six hauls in Aberdeen Bay were made by the steam-trawler "Lochryan," four of which were recorded. In the first, in from eight to fifteen fathoms of water, and which lasted for two hours and twenty minutes, 835 fishes were taken, of which 675 were marketable and 160 unmarketable. The catch included twenty-nine cod, forty-three codlings, all marketable, 399 haddocks, 338 whittings, seven plaice, a brill, and a common sole. In the second haul, in from seven and a half to twelve fathoms, for four hours and thirty-five minutes, 1066 fishes were taken, the number marketable being 930. There were 106 cod, 151 codlings, all except six marketable, four coalfish, 320 haddocks, only eleven of which were unmarketable, 308 plaice, and a number of whittings and others. The succeeding two hauls were rather better, haddocks especially being more abundant, and altogether in the four drags—the time of actual fishing being fifteen hours and twenty-five minutes—6042 fishes were taken, of which 4654 were marketable and 1388 unmarketable, the average per hour's fishing being for the whole catch 392.1, for the marketable 302.0, and for the unmarketable 90.1. The average per hour for haddocks was 196.3, for whittings 117.5, and for

plaice 33·5. The numbers of fishes of the various kinds, marketable (I.) and unmarketable (II.), were as follows :—

	Plaice.	Common Dab.	Flounder.	Lemon Dab.	Sole.	Brill.	Long Rough Dab.	Cod.
I.	507	40	5	3	2	1	-	197
II.	10	33	-	-	-	-	2	-
Total	517	73	5	3	2	1	2	197

	Codling.	Haddock.	Whiting.	Coal-fish.	Gurnard.	Thornback	Starry Ray.
I.	322	2,863	709	4	-	1	-
II.	22	162	1,101	-	9	2	47
Total	344	3,025	1,810	4	9	3	47

In a haul with the small-meshed net, which lasted for an hour, the total number of fishes taken was 1981, belonging to ten species, as follows :—

Plaice, -	-	27	Haddock, -	-	1190
Lemon Dab,	-	1	Whiting, -	-	701
Common Dab,	-	6	Gurnard, -	-	6
Long Rough Dab,	2		Sprat, -	-	2
Cod, -	-	45	Grey Skate, -	-	1

The total quantity of fish landed, in cwts., was as follows, the time of fishing (including the incompletely recorded drags) being nineteen hours and five minutes :—

Cod.	Codling.	Coal-fish.	Haddock.	Whiting.	Turbot.	Plaice.	Dabs.	
25	7½	½	21	4½	½	7	½	=66½

VI.

The next series of trawling experiments was made in November, the vessel employed being the steam-trawler “Glenogil,” and the places examined were Aberdeen Bay, Burghead Bay, the Dornoch Firth, between Burghead and Cromarty, and Smith Bank.

Four hauls were made in Aberdeen Bay on 6th and 7th November, off Newburgh, and between Black Dog and Collieston. In the first, in from eight to ten fathoms, which lasted for three hours, 1383 fishes were secured, 1314 of which were marketable and sixty-nine unmarketable. The former consisted mostly of haddocks and whittings ; of 1013 haddocks taken, 977 were marketable and thirty-six unmarketable, and of 321 whittings all but eighteen were marketable. The other fishes comprised one cod, twenty-seven codlings, a few dabs and gurnards, as well as six herrings and two sprats. Only two plaice were caught in this drag. Most of the haddocks belonged to the third and fourth classes, only 135 were “large” and sixty-nine “medium.” The smallest haddocks amongst the unmarketable measured six and seven inches in length.

The next haul in the same locality, in five and a half to twelve fathoms, lasting for two hours, yielded only seventy-one fishes, and there was nothing apparent to account for the very small catch. The marketable fish consisted of thirteen haddocks—viz., one large, six medium, and six fourths—twenty-four whittings, one plaice, and one dab. Other two hauls were made in from four and a half to twelve fathoms, but the catches were small, the marketable fishes consisting chiefly of haddocks, plaice, and whittings. Altogether in the four hauls made in Aberdeen Bay—the actual time of fishing being twelve hours and five minutes—the total number of fishes captured was 2630, the average per hour being 217·7; the number of marketable was 2394, with an average of 198·2, and the unmarketable 236, with an average of 19·5. The haddocks numbered 1485, the average per hour's fishing being 122·9; the whittings 573, with an average of 47·4, and the plaice 379, with an average of 31·3.

The numbers of the marketable (I.) and the unmarketable (II.) of each kind are shown in the following Table :—

	Plaice.	Common Dab.	Long Rough Dab.	Brill.	Cod.	Codling.	Haddock.
I.	378	27	-	2	3	77	1,417
II.	1	6	11	-	-	13	68
Total	379	33	11	2	3	90	1,485

	Whiting.	Gurnard.	Grey Skate.	Thorn-back.	Starry Ray.	Herring.	Sprat.
I.	490	-	-	-	-	-	-
II.	83	24	3	1	17	7	2
Total	573	24	3	1	17	7	2

The vessel then landed the fish which had been caught in Aberdeen Bay before proceeding to the Moray Firth, and the quantities as recorded in the market, by the Fishery Officer, in cwts. were as follows :—

Cod.	Codling.	Haddock.	Whiting.	Plaice.
$\frac{1}{4}$	1	$7\frac{1}{4}$	$1\frac{1}{4}$	2

In the Moray Firth the first place visited was Burghead Bay, where five hauls were made, four of which were recorded. In the first, which lasted for three hours and ten minutes, 1682 fishes were caught, of which 1365 were marketable and 317 unmarketable. Among the former were eleven cod, 506 haddocks, ten whittings, nine brill, 790 plaice, and thirty-four common dabs. The unmarketable were composed mostly of small haddocks and gurnards. In the second drag, lasting for four hours and fifteen minutes, 2421 fishes were taken, 1930 marketable and 491 unmarketable. The greater part of the catch again consisted of plaice and haddocks. It also included a turbot, ten brill, and a black or common sole. The number of fishes taken in the third haul, which lasted four hours, was 1779, the number marketable being 1273. They consisted

for the most part of plaice, of which 1158 were obtained. There were only seventy-five small haddocks, twenty-five marketable and fifty too small to be marketable. In this drag no less than thirty-one brill were taken, a number that is scarcely ever reached in these trawling operations, and there were also five turbot. The fourth drag lasted for two hours and thirty-five minutes, and 1131 fishes were captured, of which 733 were marketable and 398 unmarketable. Only twenty-five small and unmarketable haddocks were caught in this drag ; the marketable plaice numbered 678, and there were seven brill.

During the time of fishing in the Bay the weather was favourable, though somewhat squally, with rain, the wind blowing from the west.

The aggregate number of fishes taken in the four hauls in the fourteen hours of actual fishing was 7013, of which 5301 were marketable and 1712 unmarketable. The average catch per hour's fishing was for the marketable 378·6, and for the unmarketable 122·3 ; the average for both combined was 500·9. The number of plaice caught was 3588, the average per hour being 256·3, and the number of haddocks 1823, with an average of 130·2.

The numbers of the marketable and unmarketable of each species are given in the following Table :—

	Plaice.	Common Dab.	Witch.	Lemon Dab.	Sole	Turbot.	Brill.
I.	3,476	238	6	9	1	6	57
II.	112	584	-	-	-	-	-
Total	3,588	822	6	9	1	6	57
	Cod.	Codling.	Haddock.	Whiting.	Gurnard.	Thorn-back.	Angler.
I.	19	66	1,358	36	-	23	6
II.	-	35	465	99	396	9	12
Total	19	101	1,823	135	396	32	18

With regard to the general size of the plaice and haddocks captured, the great majority were small. Especially was this the case with the haddocks, only six of the large and forty-five of the medium being taken. The numbers of each class and the average per hour's fishing are given in the following Table :—

	Firsts.	Seconds.	Thirds.	Fourths.	Offal or Unmarketable.
Haddock,	{ 6 0·4	45 3·2	77 5·5	1,230 88·0	465 33·2
Plaice,	{ 77 5·5	575 41·1	2,824 201·7	- -	112 8·0

On leaving Burghead Bay the vessel steamed to the Dornoch Firth, where a number of hauls were made, the weather being calm and the sea smooth, a light wind coming from the north-west.

The first drag was made in from five to thirteen fathoms, off Golspie. It lasted for four hours and five minutes, and the catch was a good one, the marketable fishes numbering 2346, the unmarketable 1139, and the aggregate 3485. Plaice and haddocks formed the bulk of the catch; of the former 2166 were taken, 1264 of which were marketable and 902 unmarketable. Most of the plaice were of small size, only five being large, 167 medium, and 1092 thirds, while the offal in this haul numbered 902. Some of these, however, were quite large enough to go to market as fourths, and after this fourths were also selected. I found that the sizes of the larger specimens of the "unmarketable" plaice were on this occasion between nine and eleven inches: I give the measurements of seventy-six of the larger ones, in centimetres and inches:—



The larger of these plaice were in reality "thirds"; but the selection, as previously mentioned, is never quite exact.

The next haul, in the same locality, was for four hours and twenty-five minutes, but the fishing was chiefly conducted in from eight to ten fathoms. The number of fishes taken was 1808, of which 1368 were marketable and 440 unmarketable. Haddocks were much scarcer, only 375 being caught, and it may be said generally in regard to this fish at this time in the Dornoch Firth that the quantity taken in the various hauls varied very much, there being sometimes only a few and sometimes over a thousand. They were obviously present, as the trawlers describe it, in "spots." The plaice numbered 1237, of which 978 were marketable; there were in addition thirty-two codlings, eight whittings, four brill, twenty-two common dabs, and a thornback ray among the marketable fishes.

The number of fishes caught in the next haul, which lasted for four hours and a half, was 2514, the marketable being 1902 and the unmarketable 612. The haddocks numbered 1282, of which 271 were unmarketable. There were 995 plaice, 881 of them marketable, and in addition to these the marketable fishes included two cod, six codlings, one halibut, and one megrim. The unmarketable consisted mostly of haddocks, dabs, plaice, and gurnards. In the fifth drag, in from six to ten fathoms, only nineteen haddocks were taken, and of these thirteen were unmarketable. The plaice numbered 2101, all but 184 being marketable. The next drag, for five hours, yielded 3033 fishes, 2337 being marketable and 696 unmarketable. There were 634 haddocks, 1981 plaice, 1661 marketable, 371 common dabs, six lemon dabs, and seventeen brill.

Altogether in the six hauls, involving twenty six hours and forty minutes of actual fishing, 14,404 fishes were captured, the rate per hour being the high one of 541·5. The marketable numbered 10,919, with an average of 410·4 per hour, and the unmarketable 3485, with an hourly average of 131·0. The average per hour for the plaice taken was 350·4, and for those which were marketable 277·2; the average for the haddocks

was 140·5 per hour. The numbers of the marketable and unmarketable, and the totals, are as follow :—

	Cod.	Codling.	Haddock.	Whit- ing.	Plaice.	Common Dab.	Brill.	Lemon Dab.
I.	24	78	3,253	10	7,373	129	25	15
II.	-	31	485	4	1,948	746	-	3
Total	24	109	3,738	14	9,321	875	25	18

	Halibut.	Megrim.	Long Rough Dab.	Gur- nard.	Grey Skate.	Thorn- back.	Sandy Ray.	Angler.
I.	1	2	-	-	1	8	-	-
II.	-	-	6	213	-	35	3	11
Total	1	2	6	213	1	43	3	11

Among the haddocks the proportion of large and medium was considerable, and much above what it was on many previous occasions; medium plaice were also well represented. The following figures give the average number of each class taken per hour's fishing :—

	First.	Second.	Third.	Fourth.	Unmarketable.
Haddock,	24·6	24·6	33·3	39·6	18·2
Plaice,	1·1	43·4	137·6	95·0	73·2

In the Dornoch Firth three hauls were also made with the small-meshed net around the cod-end, in from four and a half to twelve fathoms, the time occupied in fishing being three hours and fifty minutes. The number of fishes taken in both nets amounted to 11,590, the great majority having passed through the meshes of the cod-end. They belonged to eleven species, as follows :—

Plaice, -	-	-	327	Gurnard, -	-	4
Brill, -	-	-	1	Sprat, -	-	9351
Common Dab,	-	-	28	Herring, -	-	1407
Cod, -	-	-	4	Sand-eel, -	-	3
Haddock, -	-	-	23	Thornback Ray,	-	1
Whiting, -	-	-	441			

Most of the sprats were taken in one haul, viz. 5477, and most of the herrings in another, 1297.

On leaving the Dornoch Firth the vessel returned to Burghead Bay, where other three drags were made in from five to ten fathoms, a fresh breeze blowing from the south, and a considerable number of plaice were taken. The hauls were also remarkable for the large number of brill captured, the three drags yielding in succession thirty-six, forty-three, and fifteen—a total of ninety-four. Seven turbot were also caught. The aggregate number of fishes secured in the three drags, the time of actual fishing being fourteen hours, was 5367, an average per hour of 383·4. The marketable fishes numbered 3817, with an average per hour of 272·6, and the unmarketable 1550, with an hourly average of 110·7. These averages are under those for the fishing in the same place a few

days before. In the following Table are given the number of marketable (I) and unmarketable (II.) fishes taken in the three drags :—

	Cod.	Codling.	Haddock.	Whiting.	Plaice.	Brill.
I.	84	87	190	-	3,274	94
II.	-	34	98	8	464	-
Total	84	121	288	8	3,738	94

	Turbot	Lemon Dab.	Common Dab.	Gurnard.	Thorn-back.	Angler.
I.	7	6	70	-	5	-
II.	-	3	600	322	10	11
Total	7	9	670	322	15	11

A short haul of one hour's duration was then taken off Burghead Bay, between it and Cromarty, in thirty fathoms, with the small-meshed net around the cod-end of the otter-trawl. The total number of fishes taken in both nets was 1805, belonging to fourteen species, as follows :—

Witch,	-	-	-	101	Hake,	-	-	-	2
Plaice,	-	-	-	4	Ling,	-	-	-	1
Common Dab,	-	-	-	130	Gurnard,	-	-	-	46
Long Rough Dab,	-	-	-	705	Norway Pout,	-	-	-	432
Whiting,	-	-	-	339	<i>Gadus luscus</i> ,	-	-	-	7
Haddock,	-	-	-	29	<i>Callionymus maculata</i> ,	-	-	-	2
Codling,	-	-	-	4	<i>Lumpenus lampetiformis</i> ,	-	-	-	3

Smith Bank was then visited, and a haul with the small-meshed net attached was made in twenty-one fathoms for one hour. The tying of the outer net was defective ; the knot slipped, and all the fish escaped. In the cod-end were thirty-three haddocks, three cod, five plaice, one lemon dab, five common dabs, and an angler.

The quantity of fish landed by the vessel, as recorded on returning to port amounted to 218½ cwts., as follows :—

Cod.	Codling.	Haddock.	Turbot.	Brill.
18	8½	53	½	6
Plaice.	Dabs.	Witch.	Skate.	Angler.
115	3½	¾	11	2

VII.

The next series of trawling investigations was made on board the "Lochryan," on 11th and 12th December, in Aberdeen Bay, a strong breeze blowing from the south, with a rough sea and rain. The catches were small, but, as often occurs in such conditions of weather, a considerable number of cod were secured. Three recorded hauls were made off the Black Dog in from four and a half to ten fathoms of water, the duration of the actual trawling being twelve hours and ten minutes. The total number of fishes caught in each haul was respectively 344,

243, and 191, the aggregate being 778, with the very low average per hour's fishing of 63·9. The marketable numbered 702, giving an average per hour of 57·7, and the unmarketable numbered seventy-six. The hourly average for cod was 13·0 and for codling 24·5, while it was only 16·8 for haddocks and 1·6 for plaice. The numbers of the various kinds taken were as follows :—

	Cod.	Codling.	Had-dock.	Whit-ing.	Coal-fish.	Brill.	Plaice.	Com. Dab.	Starry Ray.
I.	158	298	205	14	-	1	19	7	-
II.	-	-	-	21	5	-	-	-	50
Total	158	298	205	35	5	1	19	7	50

Two hauls were also made with the small-meshed net around the cod-end of the otter-trawl. In the first of these, which lasted for one hour and twenty minutes, and was made in from eight to twelve fathoms, the total catch was one cod, four codlings, fourteen whittings, two common dabs, one sand-eel, one goby, twenty-two small herrings (from one and three-quarter inches to nearly five inches), and seventy-four sprats. In the second, on the same grounds for one hour, but in seven fathoms, only a single fish—a starry ray—was taken.

VIII.

Towards the end of December another series of trawling investigations was carried on in Aberdeen Bay and the Moray Firth, on board the steam-trawler "Star of the Ocean." Several hauls were taken in Aberdeen Bay on the 23rd and 24th of the month, off Slains Castle, in from ten to thirty fathoms, but the net was usually torn, and the catches were very poor. In the first, which lasted for four hours and twenty minutes, 206 fishes were caught, 182 being marketable. Seventy-seven cod were taken, but only seven haddocks and sixty-six plaice, most of the latter being "thirds." In the next drag, for three hours and a half, the catch was reduced to 108 fishes, twenty-three being cod, and there was the same number of plaice, but only five haddocks. The catch of the third haul was still less, viz. sixty fish, twenty-six being cod, eight haddocks, and eleven plaice. In each case, however, the net was torn on the bottom. Two other unrecorded hauls were made, and the aggregate quantity of fish landed from the five hauls amounted to 30½ cwts., viz. 22 cwts. of cod, 2½ cwts. of codlings, 2½ cwts. of haddocks, 1½ cwts. of plaice, and 1¼ cwts. of skates.

On the 25th a number of drags were taken at Burghead Bay, in the Moray Firth, the wind being light, from the south-west, and the weather foggy, and with much better results. In the first of the two recorded, which was in from eight to eleven fathoms, for five hours and five minutes, 1149 fishes were taken, 353 marketable and 796 unmarketable. The catch was chiefly made up of haddocks, mostly small; of a total of 727, the number thrown overboard as unmarketable was 604; there were only three large and no mediums. The second haul, for five hours and ten minutes, yielded 3055 fishes, of which 784 were marketable and 2271 unmarketable. The total number of haddocks captured was 2458, and of these 2086 were too small to be marketable. In the two hauls, the time of fishing being ten hours and fifteen minutes, 4204 fishes were

taken, 1137 marketable and 3067 unmarketable. The numbers of the two classes are as follows :—

	Cod.	Codling.	Haddock.	Whiting.	Plaice.	Brill.	Com. Dab.	Turbot.	Lemon Dab.	Gurnard.	Long Rough Dab.
I.	12	9	495	196	366	21	35	2	1	-	-
II.	-	26	2,690	228	14	-	91	-	-	11	7
Total	12	35	3,185	424	380	21	126	2	1	11	7

The very foggy weather which prevailed interfered with fishing operations near the shore ; partly for this reason the vessel shifted its position and made a haul in from sixteen to twenty-five fathoms off Tarbet Ness. The drag lasted for one hour and forty-five minutes, and it was found that the net was considerably torn. The catch was small, amounting to 543 fishes, of which 431 were marketable and 112 unmarketable. The number of haddocks taken was 338, of which 315 were marketable ; there were seventy plaice, fifty-two being marketable, thirteen marketable codlings, five coal-fish, forty-two whittings, twenty-seven marketable, as well as six lemon dabs and sixty-three common dabs.

Two or three hauls were then made in the Dornoch Firth, in from seven to twelve fathoms, but the work was difficult owing to the thick fog, and in one of the drags the net was foul and came up without any fish. In a recorded haul, which lasted for four hours, the number of fishes caught was 1095, of which the marketable amounted to 933 and the unmarketable to 162. The catch included 825 haddocks, all but 55 being marketable, as well as eight cod, two turbot, four brill, 148 plaice, and some dabs. On the 27th a haul was made for sixty-five minutes, in from eight to ten fathoms, with the small-meshed net, around the cod-end. The total number of fishes taken in the two nets was 880, belonging to sixteen species. On the following day another similar drag was taken with the small-meshed net for an hour, and they may be both considered together. The following is a list of the numbers of each kind of fish caught in the two drags, nineteen species being represented, and the total being 3657 fishes :—

Plaice,	122	Gurnard,	10
Lemon Dab,	4	Sprat,	808
Common Dab,	845	Herring,	4
Long Rough Dab,	24	Pogge,	8
Little Sole,	18	<i>Gobius minutus</i> ,	2
Brill,	4	Dragonet,	4
Witch,	1	Common Pipe-fish,	3
Cod,	20	Angler,	8
Haddock,	57	Thornback,	7
Whiting,	1,708		

From the Dornoch the vessel steamed to the grounds off Lybster, where a drag was made for four hours and a quarter in from eighteen to twenty-two fathoms. The net was found to have been badly split on coming up, and the catch was very small, amounting to only sixty-two fishes, all marketable. The catch included two cod, forty-four haddocks, and a few plaice and whittings.

The next place visited was Smith Bank, where a haul was made in twenty-seven and twenty-eight fathoms, on the edge of the bank, for

sixty-five minutes, the small-meshed net being around the cod-end. The total number of fishes taken was considerable, viz. 1673, and they belonged to twenty-one species; some of them, as the young conger (*Leptocephalus*) and the thick-back sole, were of much scientific interest.

Plaice,	19	Sprat,	6
Lemon Dab,	20	Gurnard,	8
Common Dab,	1,124	Goby (sp.),	6
Little Sole,	47	Pogge,	8
Thickback,	1	Gemmeous Dragonet,	14
Long Rough Dab,	3	Spotted Dragonet,	2
Haddock,	25	Sand-eel,	54
Whiting,	141	<i>Leptocephalus</i> ,	1
Cod,	38	Piked Dog-fish,	1
Norway Pout,	158	Starry Ray,	1
Poor Cod,	1		

From the commercial point of view, however, the fishing on Smith Bank was not of a profitable kind, and the vessel returned to Burghead Bay on the 28th, where a number of hauls were taken, three of which were completely recorded. In the first, which was for five hours and a quarter, in from five to thirteen fathoms, 1198 fishes were taken, of which 567 were marketable and 631 unmarketable. The catch included nine cod, thirty-two codlings, all but seven marketable, 713 haddocks, the majority being again very small and 540 of them unmarketable, three turbot, thirty-seven brill, 306 plaice, all marketable, and a few others.

The second drag, for five hours, yielded only 269 fishes, of which 110 were marketable. Of 120 haddocks caught only three were marketable, and the other marketable fishes comprised one turbot, nine brill, sixty-three plaice, and twenty-seven common dabs. The third haul, in from four and a half to ten fathoms, was even less productive, only 193 fishes being caught, of which 111 were marketable and 82 unmarketable. None of the fifty-six haddocks taken were marketable, but there were seven brill and ninety-nine plaice, a cat-fish, two cod, and a thornback ray.

In the three hauls, occupying altogether fourteen hours and a quarter of actual fishing, only 1660 fishes were taken, 788 being marketable and 872 unmarketable. The general average per hour's fishing is thus a very low one, viz. 116·5, while the average for the marketable alone is 55·3. The particulars regarding the different kinds of fish are given in the following Table:—

	Cod.	Codling.	Haddock.	Whiting.	Plaice.	Turbot.	Brill.
I.	18	25	176	-	468	4	53
II.	-	16	713	40	-	-	-
Total	18	41	889	40	468	4	53

	Common Dab.	Lemon Dab.	Gurnard.	Cat-fish.	Long Rough Dab.	Thorn-back.
I.	37	3	-	2	-	2
II.	79	-	22	-	2	-
Total	116	3	22	2	2	2

A haul with the small-meshed net was also taken in Burghead Bay for seventy-five minutes, in from five to twelve fathoms, and the total number of fish caught was only 173, as follows:—

Plaice,	45	Whiting,	59
Common Dab,	11	Sprat,	7
Brill,	4	Herring,	3
Turbot,	1	Long Rough Dab, ...	1
Cod,	6	Sand-eel,	2
Haddock,	34		

Another drag with the small-meshed net was taken on the so-called “witch ground” between Burghead Bay and the Suters of Cromarty, in thirty and thirty-one fathoms, and it lasted for an hour. The total number of fishes caught was 2112, belonging to twenty species. The numbers of each kind are as follows:—

Halibut,	1	Norway Pout,	307
Witch,	73	Hake,	2
Plaice,	6	Herring,	31
Common Dab,	151	Sprat,	356
Long Rough Dab, ...	696	Sand-eel,	1
Thickback Sole, ...	1	<i>Lumpenus</i> ,	6
Cod,	3	Goby (sp.)	1
Haddock,	1	Angler,	1
Whiting,	470	Starry Ray,	3
Gurnard,	1	Thornback,	1

Before the vessel left the Moray Firth a few hauls were taken at night off Lossiemouth in twenty and twenty-one fathoms, but the net suffered much and was usually found split when it was hauled. The particulars of these hauls were not recorded; but in the first the catch included two baskets of large haddocks, one basket of mediums, and three baskets of thirds, as well as two cod, twenty lemon dabs, half a basket of plaice, and half a basket of whittings. The offal thrown overboard consisted of seven basketfuls, mostly of small haddocks.

On the way to port a small-meshed drag was taken in Aberdeen Bay on 29th December. It was made in from eight to seventeen fathoms, and lasted for an hour. The total number of fishes caught was 4270, the great bulk consisting of small whittings. The numbers of the various species are as follows:—

Plaice,	10	Herring,	16
Common Dab,	5	Sprat,	39
Long Rough Dab, ...	5	Gurnard,	1
Haddock,	173	Pogge,	2
Cod,	9	Liparis,	2
Whiting,	4,007	Sand-eel,	1

The total quantity of fish, in cwts., landed from this trip was recorded by the Fishery Officer as follows:—

Cod. 18½	Codling. 2	Coal-fish. ½	Haddock. 27½	Whiting. 3½	Turbot. ½	Halibut. ½
Brill. 1½	Lemon Dab. 1	Plaice. 28½	Dabs. 1½	Witches. ½	Cat-fish. ½	Skate. 1

The quantity was small, considering the duration of fishing, but the foggy weather which prevailed for a large part of the time somewhat hampered the operations. It was noticed also that young herrings and sprats did not form so large a proportion of the small fishes caught in the small-meshed net as was usually the case. Foreign trawlers, moreover, were observed to be fishing in some numbers in the Firth at the time, and three of them were working along with us on Smith Bank.

IX.

In August a record was kept of the hauls made by the steam-trawler "Glenogil" on the fishing grounds lying off the mouth of the Firth of Forth. The vessel left Aberdeen on the 17th August, and ran for about sixty miles on a course S. $\frac{1}{2}$ E. from Girdleness, and continued fishing southwards for several days, landing the catches at Granton, to about thirty-four miles S.E. of the Isle of May. The weather was good and the sea calm. The grounds visited on this trip, as may be seen from a chart, lie off St. Abb's Head and the coast of Berwickshire and Northumberland, and are much fished by the trawlers belonging to Granton.

The first drag was made in thirty-four and thirty-five fathoms, about thirty miles E. $\frac{1}{2}$ S. of the Isle of May, and it lasted for three hours. The catch was a moderate one, the number of fishes taken being 608, of which only 381 were marketable. They consisted almost entirely of haddocks, which numbered 519, the marketable numbering 360; the other marketable fishes were seven codlings, nine whittings, and five lemon dabs. The unmarketable were made up of haddocks, whittings, and gurnards. The next three shots were much the same both in regard to species and amount, the bulk of the catches being composed of haddocks, but there were in addition a few cod, coal-fish, plaice, and ling. Afterwards the catches improved. In the sixth haul, which was for three hours and five minutes, 2145 fishes were captured, 1713 being marketable. The haddocks numbered 1755, of which 1535 were marketable; there were also 130 marketable whittings, one cod, nineteen codlings, twelve plaice, and sixteen lemon dabs. The unmarketable consisted entirely of haddocks, whittings, and gurnards.

Succeeding hauls were nearly as productive, the totals varying from 1243 to 2991, the duration of the drags being generally a little over three hours. In all of them haddocks formed the great bulk of the catch, the rest of the marketable fishes being made up of whittings, codlings, a few cod, ling, and coal-fishes; the flat-fishes were represented by small numbers of lemon dabs, plaice, and common dabs.

Altogether, in twelve hauls, up to the afternoon of the 19th August, the time of actual fishing being thirty-nine hours and twenty minutes, the number of fishes caught was 17,569, of which 13,874 were marketable and 3695 unmarketable. The average number taken per hour's fishing was 353.0 for the marketable, 94.0 for the unmarketable, and 447.1 for both combined.

The totals of each kind are given in the following Table, the marketable (I.) being distinguished from the unmarketable (II.):—

	Cod.	Codling.	Haddock.	Whiting.	Coal-fish.	Ling.	Hake.
I.	27	373	12,464	711	19	8	1
II.	-	89	2,264	695	-	-	-
Total	27	462	14,728	1,406	19	8	1

	Plaice.	Lemon Dab.	Common Dab.	Long Rough Dab.	Gurnard.	Angler.
I.	92	176	3	-	-	-
II.	-	-	35	85	514	13
Total	92	176	38	85	514	13

The haddocks were by far the most important part of the catch, the average number taken per hour being 374·7 ; the rate for the marketable was 317·1 and for the unmarketable 57·6. The particulars for the majority of the fishes, showing the rate per hour, are as follows :—

	Marketable.	Unmarketable.	Total.
Haddock,	317·1	57·6	374·7
Whiting,	18·1	17·6	35·8
Codling,	9·5	2·2	11·7
Lemon Dab,	4·5	—	4·5
Plaice,	2·3	—	2·3
Gurnard,	—	13·1	13·1

On the 20th and 21st August a number of other hauls were made about fifty miles E. by S. from the Isle of May, off the coast of Northumberland, in from thirty-four to thirty-six fathoms. The catch was of much the same character, consisting mostly of haddocks, with some whittings, codlings, plaice, lemon dabs, common dabs, gurnards, and an occasional cod.

The record of one of the hauls was not completely taken, the unmarketable fishes being omitted, but in the other four, the time of actual fishing being thirteen hours and twenty minutes, 7257 fishes were taken, the number of marketable being 6342 and of unmarketable 915. The average per hour's fishing was thus 476·8 for the marketable and 68·8 for the unmarketable, the general average being 545 6. The total number of haddocks caught was 6292, of which 5811 were marketable ; 443 whittings were taken, 294 being marketable, 140 codlings, forty plaice, eighty-one lemon dabs, and some others.

The averages per hour's fishing agree very well with those of the previous hauls above referred to :—

	Marketable.	Unmarketable.	Total.
Haddock,	436·9	36·1	473·1
Whiting,	22·1	12·2	33·3
Codling,	8·1	2·4	10·5
Lemon Dab,	6·0	—	6·0
Plaice,	3·0	—	3·0
Gurnard,	—	12·4	12·4

TRAWLING INVESTIGATIONS—TABLE I.



TRAWLING INVESTIGATIONS—TABLE I.

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TRAWLING INVESTIGATIONS—TABLE I.

1881

1882

1883

1884 1885

TRAWLING INVESTIGATIONS—TABLE I.

TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date.	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Air.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No. thrown Over- board.	Total No.	
Greenhead, off burgh.	1903. Mar. 16.	..	..	..	13 to 19	2.50 a.m.	6.50 a.m.	Cod, Codling, Haddock, Gurnard, Plaice, Flounder, Thornback,	123 195 4 .. 156 .. ..	.. .. .. 1 28 2 5	123 195 4 1 184 2 5	Wind S.S.E.
									478	36	514	
Same place.	..	..	..	..	12 to 18	7.20 a.m.	11.40 a.m.	Cod, Codling, Coal-fish, Haddock, Whiting, Plaice Lemon Dab, Witch, Com. Dab,.. .. Starry Ray, Grey Skate, Thornback,	8 4 1 84 .. 20 4 .. .. .. .. ..	.. .. .. 8 7 2 .. 2 3 1 16 45	8 4 1 92 7 22 4 2 3 1 16 45	Heavy Sea.
									121	84	205	
Greenhead New- burgh to south.	..	..	..	..	8 to 16	12.15 p.m.	4.20 p.m.	Cod, Codling, Coal-fish, Haddock, Plaice, Witch, Com. Dab,.. .. Flounder, Grey Skate, Thornback, Lumpsucker,	47 126 1 3 92 .. .. .. .. .. ..	.. .. .. .. 53 2 30 12 1 7 1	47 126 1 3 145 2 30 12 1 7 1	
									269	106	375	
Foray orth head. ay.	Mar. 17.	..	..	..	7 to 12	4.35 p.m.	8.25 p.m.	Cod, Codling, Haddock, Turbot, Brill, Plaice Com. Dab,.. .. Flounder, Cat-fish, Gurnard, Thornback, Starry Ray, Angler,	4 3 2 1 11 329 70 14 3 2	.. 1 204 1 4 2 1	4 4 2 1 11 329 274 14 3 1 4 2 3	
									439	213	652	
Same place.	Mar. 17 & 18.	9 p.m.	1.15 a.m.	Cod, Codling, Haddock, Whiting, Brill, Plaice, Lemon Dab, Com. Dab, Flounder, Cat-fish, Thornback, Starry Ray, Sandy Ray, Angler, Herring,	2 4 5 226 1 56 8 4 3 4 3 3 44 32 1 264 12 2 4 24 3	2 7 44 32 6 226 1 220 8 4 15 6 7 24 3	
									816	389	705	

TRAWLING INVESTIGATIONS—TABLE I.

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TRAWLING INVESTIGATIONS—TABLE I.




TRAWLING INVESTIGATIONS—TABLE I.

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188 188

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TRAWLING INVESTIGATIONS—TABLE I.

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TRAWLING INVESTIGATIONS—TABLE I.

1874

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1876

1877

1878

1879

1880

1881

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TRAWLING INVESTIGATIONS—TABLE I.

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TRAWLING

I.

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TRAWLING INVESTIGATIONS—TABLE I.

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TRAWLING INVESTIGATIONS--TABLE I

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TRAWLING

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I.

TRAWLING INVESTIGATIONS—TABLE I.

1881

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1882

1883

Part III.—Twenty-second Annual Report

TRAWLING

I.

Place.	No. OWN re- ard.	Total No.	Remark
14. About 50 miles E. by S. from Isle of May	17	35	
	09	2230	
	40	170	
	.	20	
	.	31	
	9	0	
	23	23	
	47	47	
	3	3	
	147	2568	
15. Same Locality.	8	5	
	.	50	
	.	.	
	90	1367	
	32	92	
	.	23	
	8	8	
	15	15	
	62	52	
	1	1	
	2	2	
	214	1621	
16. Same Locality.	7	2	
	.	40	
	.	1	
	209	2054	
	46	150	
	.	10	
	.	20	
	4	4	
	7	7	
	43	43	
	2	2	
	3	3	
	221	2345	
17. Same Locality.	09	641	
	31	31	
	.	10	
	.	7	
	4	4	
	7	7	
	23	23	
	33	723	

TRAWLING INVESTIGATIONS—TABLE 1.

Place.	Date.	Temperature	
		Air.	Surface.
Same salley.	1903. Aug. 21.

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TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date.	Operator.	Fish Caught.				Remarks
			Name.	No. taken to Market.	No. thrown Over-board.	Total No.	
1. Aberdeen Bay, off Black Dog.	1903. Oct. 16.		Cod,	13	..	13	Wind S.W., a breeze; sea r
			Codling,	118	3	121	
			Haddock (1), ..	740	..	..
			" (2), ..	282	..	..
			" (3), ..	530	..	..
			—	1517	..	1517	
			Whiting,	259	5	264	
			Brill,	1	..	1	
			Plaice (1), ..	13	..	..
			" (2), ..	9	..	..
			" (3), ..	22	..	22	
			Lemon Dab, ..	1	..	1	
			Com. Dab, ..	5	23	28	
			Grey Skate, ..	2	..	2	
			Gurnard, ..	..	8	8
			Angler, ..	..	1	1
			—	1938	40	1978	
			—	
			—	
			—	
2. Aberdeen Bay, off Old Castle.	"	T. W. W.	Cod,	4	..	4	
			Codling,	273	9	282	
			Haddock (1), ..	395	..	..
			" (2), ..	164	..	..
			" (3), ..	540	..	..
			—	1099	..	1099	
			Whiting,	261	14	275	
			Brill,	10	..	10	
			Plaice (1), ..	12	..	..
			" (2), ..	108	..	..
			" (3), ..	13	..	..
			—	194	..	194	
			Lemon Dab, ..	12	..	12	
			Com. Dab, ..	28	45	73	
			Starry Ray, ..	8	2	5	
			Grey Skate, ..	6	1	6	
			Gurnard, ..	..	4	4
			—	1899	75	1964	
			—	
			—	
3. Same Locality.	"	—	Cod,	26	..	26	
			Codling,	179	11	190	
			Haddock (1), ..	241	..	..
			" (2), ..	254	..	..
			" (3), ..	170	..	..
			—	665	..	665	
			Whiting,	96	16	112	
			Brill,	8	..	8	
			Plaice (1), ..	10	..	..
			" (2), ..	171	..	..
			" (3), ..	14	..	..
			—	196	..	196	
			Lemon Dab, ..	14	..	14	
			Com. Dab, ..	24	37	61	
			Gurnard, ..	..	5	5
			Thornback, ..	4	..	4	
			Grey Skate, ..	5	1	6	
			Angler, ..	..	1	1
			—	1216	71	1287	
			—	
			—	

TRAWLING

I.

~~1885~~

Remarks.

Small-meshed net.

Weather calm.
Catch included
3½ baskets of
haddocks, mostly
small, and six of
plaice.

TRAWLING INVESTIGATIONS—TABLE I.

TRAWLING

TABLE I.

TRAWLING INVESTIGATIONS—TABLE I.

 Remarks

 2

 2

 Net split.

TRAWLING INVESTIGATIONS—TABLE I.

1884

1885

1886

1887

1888

TRAWLING INVESTIGATIONS—TABLE I.

54

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TRAWLING INVESTIGATIONS—TABLE I.

TRAWLING INVESTIGATIONS—TABLE I.

TRAWLING INVESTIGATIONS—TABLE I.

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 8
 9
 10
 11
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TRAWLING INVESTIGATION

TABLE I.

Place.	Date	Remark
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TRAWLING INVESTIGATIONS—TABLE 1.

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TRAWLING INVESTIGATIONS—TABLE I.

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TRAWLING**I.**

TRAWLING INVESTIGATIONS—TABLE II.
Giving particulars as to Boxes of Fish brought to Market.
LARGE HADDOCKS.

No. of Fish.	Length—Cm.		Weight.		Remarks.
	Range.	Average.	In Bulk.	Separately.	
142	33·2-67·5	36·7	Lbs. Oz. 140 4	Lbs. Oz.	
114	33·4-67·3	41·4	... ..	132 14	
128	27·6-48·6	38·8	127 8	126 2	
78	36·8-57·6	45·4	143 —	139 14	From Farøe.
85	36·1-60·5	45·3	149 9	148 10	" "
114	37 —54·2	...	134 4	...	
111	36·1-54·5	...	127 12	...	
110	37 —60·1	...	129 12	...	
28	50 —71·4	61·6	127 3	126 10	From Iceland.
117	36·7-59·5	...	135 —	...	
127	34·2-64·0	...	136 —	...	
87	38 —62	...	132 7	...	
94	36·5-56	...	136 —	...	
87	39·0-64	...	137 4	...	
87	38·2-58·8	...	130 —	...	
115	33 —53	...	130 13	...	
135	34 —51	40·7	137 8	134 8	
111	36 —52·3	...	127 2	...	
132	31·7-54	...	106 —	...	
148	33 —37	...	106 5	...	
130	36·2-49·5	...	112 14	...	
134	33·5-50·7	...	110 12	...	
122	33 —66·3	42·0	136 8	135 12	
120	34·2-51	42·0	134 3	133 3	
103	36·5-52·3	...	131 2	..	
95	35·5-54·3	...	127 13	...	
90	34·6-57	...	130 —	...	
96	35·5-52	...	121 8	...	
101	29·5-51·6	...	135 5	...	
102	36·9-54·5	...	140 4	...	
95	35 —54·7	...	137 3	...	
102	35 —56·7	...	144 14	...	
95	36 —59·7	...	131 14	...	
94	37·1-57·4	...	130 8	...	
95	34·8-60·5	...	127 3	...	
97	35·8-55·6	...	131 7	...	
35	50·5-70·8	59·2	122 10	..	Extra L.
35	52·7-73·5	60·3	128 3	..	"
35	51·4-72·8	60·1	133 14	..	"
37	51·6-68·8	58·7	132 —	...	"
38	50·7-66·9	58·5	127 15	...	"
35	50·3-70	59·7	122 15	...	"
83	34·7-63·1	44·9	131 6	...	

TRAWLING INVESTIGATIONS—TABLE II.

MEDIUM HADDOCKS.

No. of Fish.	Length—Cm.		Weight.		Remarks.
	Range.	Average.	In Bulk.	Separately.	
			Lbs. Oz.	Lbs. Oz.	
186	30·3-37	33·2	124 3	...	Also 1 codling 36·9.
180	31 -38	33·8	...	118 11½	
180	28·8-41·3	34·5	121 4	119 -	
175	28·6-39·5	34·5	119 8	118 8	
209	30·9-38·1	34·1	128 8	126 10	
209	31·3-37·6	34·0	126 12	123 4	
159	31·6-40·6	...	118 4	...	
233	29·8-35·1	...	120 12	...	
221	29·6-37·1	33·1	118 8	117 13	
223	30 -38·2	34·3	124 6	122 14	Also 1 whiting 28·0 cm., 4 oz.
185	32·6-38·5	...	130 -	...	
179	30·3-40·3	...	126 8	...	
180	28·9-44·9	...	129 4	...	
169	30·1-40·	..	121 10	...	
190	26·7-40·6	..	121 -	..	
184	29·5-38·2	..	126 8	...	
176	32· -39·4	..	124 8	...	
173	29·8-39·7	...	124 5	..	
168	30·4-41·	...	120 7	..	
207	31·0-38·5	...	124 12	..	
195	28 -39·4	..	123 2	..	
158	27·8-53·2	36·4	123 12	121 9	
151	32·2-48·5	..	123 8	...	
226	27·3-40·6	32·6	128 11	...	
167	26·8-38·	...	108 4	...	
192	28·4-40·6	...	126 9	...	
230	30·2-39·6	...	139 -	..	
181	31·4-41·3	...	129 -	...	
212	29·5-37·5	...	121 12	...	
209	26·9-40·1	..	124 1	...	
222	29·6-43·9	...	126 9	...	
189	25·3-39·	...	123 6	..	
177	28·7-40·2	...	122 3	..	
182	27·6-38·9	...	125 14	..	
148	32·4-48·4	...	124 19	...	

TRAWLING INVESTIGATIONS—TABLE II.

SMALL HADDOCKS.

No. of Fish.	Length—Cm.		Weight.		Remarks.
	Range.	Average.	In Bulk.	Separately.	
			Lbs. Oz.	Lbs. Oz.	
287	22·4–30·2	...	103 –	...	Also 5 whittings and 6 codlings.
246	26·3–25·	30·3	110 13	105 4	
259	22·8–35·1	...	111 4	..	
264	24·6–36·7	31·0	120 –	120 2	Also 1 whiting 30·1 and 5 oz.
280	24·8–30·7	...	119 6	...	
262	27·9–33·4	...	112 15	...	
247	27·5–36·4	32·5	114 15	114 –	
240	26·6–36·6	31·5	116 6	...	
247	26·1–36·0	31·6	122 8	122 4	
255	26·8–35·6	31·9	128 12	126 12	
293	24·4–36·4	31·1	134 –	...	
268	25·6–36·2	...	121 2	...	
273	23·2–33·6	30·2	114 8	...	
269	23·1–33·5	31·1	114 8	...	
257	21·9–33·8	30·4	106 12	...	
277	24·2–34·8	30·6	117 10	...	
271	23·1–34·3	30·	103 12	...	
268	24·7–33·5	30·3	108 5	...	
287	22·8–34·3	29·9	113 13	...	Also 2 whittings 41·1 and 46·3 cm.
249	24·3–34·3	...	103 12	...	
247	21·6–34·7	...	101 10	...	
273	21·9–33·7	...	107 12	...	
278	23·1–34·7	...	110 4	109 8	
261	21·7–34·6	...	113 2	...	Also 1 whiting 43·5 cm.
258	25·0–35·6	30·2	108 8	107 12	
319	24·5–36·6	29·4	123 0	122 15	
216	27·0–34·6	...	104 12	...	
231	28·2–34·1	...	108 2	...	
203	27·8–34·8	31·5	102 15	...	
274	26·8–33·2	...	122 2	...	
270	24·3–34·8	30·7	127 4	127	
223	26·9–36·0	31·4	109 12	...	
208	27·4–37·0	32·5	115 –	113 2	
221	27·6–34·6	...	110 4	...	
211	28·1–35·3	...	102 13	...	
250	25· –35·1	...	114 2	...	
248	23·4–33·9	...	105 7	...	
241	24·8–35·5	...	106 14	..	
226	26·3–34·5	...	105 –	...	
228	26·4–34·9	...	104 10	...	
255	24·8–35·2	...	107 –	...	

TRAWLING INVESTIGATIONS—TABLE II.
CODLING.

No. of Fish.	Length—Cm.		Weight.		Remarks.
	Range.	Average.	In Bulk.	Separately.	
			Lbs. Oz.	Lbs. Oz.	
39	38·2–66·8	56·6	...	114 15½	Also 1 cat-fish, 2 lbs. 5½ oz.
85	36·1–60·5	45·3	149 9	148 10	
51	30·4–73	49·6	127 6	126 9	
47	30·3–69·6	48·1	124 13	118 14	Also 1 ling, 73·6 cm., 5 lbs. 2 oz.
77	29·5–71·9	...	133 –	...	Also 1 ling, 53 cm., and 1 whiting.
30	34 –77·5	...	125 –	...	
35	41·5–74·9	...	156 4	...	
42	28 –68·8	...	125 6	...	
39	41·2–73	...	128 9	...	
36	38 –74	...	132 13	...	Also 1 ling, 58 cm.
70	28·5–66·5	...	137 5	...	
44	30·3–76	51·2	127 10	125 9	Also 1 ling, 1 lb. 12 oz.
34	36·1–75·1	...	122 12	...	
74	29 –70·4	...	131 –	...	
40	28·5–72	...	124 –	..	
47	34·9–71·8	...	131 14	...	
26	50·4–78·3	...	125 8	...	
68	28·2–78·5	...	135 3	...	
51	37·2–75·	50·4	136 12	135 8	
68	31·2–65·1	43·5	132 12	131 10	
53	34·4–71·9	50·6	139 –	138 2	
58	33·2–80·8	45·7	135 –	134 8	
35	36·5–71·1	54·0	125 4	121 1	Also 1 ling, 60·6= 2 lbs. 8 oz.
40	34·8–71·6	51·5	...	128 9	
26	42·4–70·4	59·0	...	116 –	Ungutted.
56	28·3–62·6	39·6	...	93 7	„

TRAWLING INVESTIGATIONS—TABLE II.
WHITING.

No. of Fish.	Length—Cm.		Weight.		Remarks.
	Range.	Average.	In Bulk.	Separately.	
			Lbs. Oz.	Lbs. Oz.	
155	30·3–53·5	38·	...	125 2	Also 1 haddock, 1 lb. 10 oz.
180	28·1–45·5	35·9	131 3	130 11	Also 1 haddock, 34·0 = 6 oz.
157	30 –52·4	...	128 12	...	
192	28·6–46·3	...	129 4	...	
216	24·2–48·1	34·3	91 5	91 5	
260	24·7–44·7	...	109 11	...	Also 1 haddock, 32·0 and 1 codling, 43·2.
218	22·2–46·7	...	94 6	...	Also 2 haddocks, 31·8, 28·8, and 1 codling, 38·3.
183	27·3–43	33·2	117 4	113 10	Line, ungutted.
123	32·2–44·2	36·6	106 –	97 12	Do. do.
183	27·9–34·7	31·0	87 7	86 5	Do. do.
138	29·2–45	34·9	103 –	101 9	Do. do.
85	31·9–46·2	37·2	90 9	86 10	Do. do.
225	27·3–40·2	32·1	118 5	116 12	Also 4 haddocks 25·5 —27·2=1 lb. 4 oz.

TRAWLING INVESTIGATIONS—TABLE II.
SMALL WHITING.

No. of Fish.	Length—Cm.		Weight.		Remarks.
	Range.	Average.	In Bulk.	Separately.	
			Lbs. Oz.	Lbs. Oz.	
279	24·3–33·5	29·5	106 5	103 13	Round, ungutted. Also 3 haddocks = 10 oz.
351	20·6–32·6	26·4	97 13	96 5	Line, gutted.
415	20·8–33·9	...	113 4	...	Also 1 haddock 21·0 cm.
274	24·7–33·7	28·5	92 –	90 2	Line, gutted.
257	23·1–36·5	27·3	91 14	89 14	Line, ungutted.

LARGE PLAICE.

No. of Fish.	Length—Cm.		Weight.		Remarks.
	Range.	Average.	In Bulk.	Separately.	
			Lbs. Oz.	Lbs. Oz.	
60	40 –56·8	...	136 15	...	
24	55·7–73·5	...	140 11	...	
24	51·0–69·3	...	141 2	...	
27	55·1–64·0	...	144 4	...	
26	50·8–66·0	...	150 4	...	
27	53·4–68·2	...	140 12	...	
35	47 –59·7	...	129 4	...	
24	55·3–72	...	139 8	...	
25	52·8–69·7	60·4	149 1	...	
42	33·7–67·9	...	135 9	...	
11	57·9–87·6	74·8	138 6	...	
17	52·6–80·8	64·0	132 13	...	
15	55·9–78·8	66·2	132 12	...	
21	56· –73·3	63·1	147 10	...	
23	55·1–68·3	60·4	139 14	...	
24	54·7–68·4	60·1	144 –	...	
23	55·7–68·7	60·7	135 11	...	
23	54·3–70·1	61·4	146 12	...	

TRAWLING INVESTIGATIONS—TABLE II.

MEDIUM PLAICE.

No. of Fish.	Length—Cm.		Weight.		Remarks.
	Range.	Average.	In Bulk.	Separately.	
			Lbs. Oz.	Lbs. Oz.	
144	30 -53·0	35·8	131 6½	...	
134	29·2-47·5	34·2	135 13	...	
66	30·6-50·6	41·3	129 -	128 1	
109	30·7-46·2	36·6	126 8	...	
89	30·1-55·4	38·6	131 5	...	
73	33·2-55·5	42·2	125 5	125 10	
90	33·7-54	...	133 -	...	
88	33·6-51·5	...	132 -	...	
84	33·6-64·5	39·0	137 15	137 12	
79	30·5-52	40·0	127 5	126 12	
61	32·3-57·7	43·3	...	124 13	
47	38·2-59·2	46·0	119 4	117 12	
115	30 -57	35·6	128 8	128 1	Small, medium.
60	33·4-54·5	...	148 -	...	
56	31·6-56·7	...	145 -	...	
56	32·7-54·8	...	135 -	...	
54	29·2-56·5	...	121 -	...	
59	33·3-54·5	...	147 8	...	
59	33·6-60·9	...	137 12	...	
63	29·9-53·4	...	139 12	...	
54	28·6-53·4	...	135 3	...	
58	32 -56·8	...	143 6	...	
66	32·4-51	...	137 14	...	
70	33·1-54·6	...	144 12	...	
75	35 -51	...	140 7	...	
63	32·2-51·4	...	142 2	...	
66	33·5-57·1	42·6	130 13	129 8	
74	33·1-54	44·1	128 15	128 14	
122	30·4-44·9	34·8	129 8	129 6	
96	30·5-56·8	36·8	140 3	...	
89	31·5-48·1	...	138 13	..	

TRAWLING INVESTIGATIONS—TABLE II.
SMALL PLAICE.

No. of Fish.	Length—Cm.		Weight.		Remarks.
	Range.	Average.	In Bulk.	Separately.	
			Lbs. Oz.	Lbs. Oz.	
205	22·3–36·2	29·4	...	126 7	
215	24·1–35	29·4	131 13½	...	
210	23·4–35·6	...	128 –	..	
217	22·8–36	...	129 8	..	
150	26·3–39·6	32·5	129 10	...	
107	31·4–40·2	...	118 10	...	
145	24·7–38·4	...	141 3	...	

TRAWLING INVESTIGATIONS—TABLE II.
LARGE WITCHES.

No. of Fish.	Length—Cm.		Weight.		Remarks.
	Range.	Average.	In Bulk.	Separately.	
			Lbs. Oz.	Lbs. Oz.	
133	32·7–47·8	39·7	...	125 1½	Also 3 megrims=3 lbs. 10½ oz. Also 1 megrim=1 lb. 7 oz.
143	33·6–49·7	39·4	...	121 8	
113	32·5–49·3	43·2	...	134 4	Also 1 megrim=8 oz.
119	32 –50	42·7	...	137 12	
129	31·8–53	39	125 4	123 7	
131	33·5–49·6	...	121 13	...	
115	31·0–50·3	38·3	136 13	136 4	
143	29·8–48·1	...	142 7	...	
137	30·1–48	...	132 –	...	
152	30·8–47·5	...	128 8	...	
161	33 –45·7	...	133 3	...	
156	31·3–47·5	38·7	186 10	135 12	
160	32·3–50·1	...	127 13	...	Gutted.
125	32·4–49	41·6	123 8	122 15	
99	32·8–53·6	40·7	122 6	121 1	

TRAWLING INVESTIGATIONS—TABLE II.
LARGE LEMON DABS.

No. of Fish.	Length—Cm.		Weight.		Remarks.
	Range.	Average.	In Bulk.	Separately.	
			Lbs. Oz.	Lbs. Oz.	
115	28·5–44·3	35·3	142 –	138 12	
99	29·9–45·7	37·6	145 4	145 8	
100	28·7–46·0	...	134 –	...	
93	29·7–46·7	38	147 15	145 3	
104	28·1–48·2	...	147 12	...	
115	28·8–47·6	35·8	151 6	150 0	
89	26·4–47·7	...	135 6	...	
91	26·9–45·2	...	134 11	...	
97	27·0–45	37·6	142 7	141 5	
88	28·1–48·1	37·5	127 15	126 11	
93	31 –44·7	...	140 1	...	
85	30·5–46·6	...	141 2	...	
88	26·4–46·3	...	140 14	...	
84	27·6–46·7	39·0	141 9	140 12	
110	29 –46·4	36·9	142 4	141 13	
83	28·8–47·4	38·2	129 6	129 0	
114	29 –46·0	36·0	149 5	146 10	
84	32·1–45·9	...	146 13	...	

COMMON DABS.

No. of Fish.	Length—Cm.		Weight.		Remarks.
	Range.	Average.	In Bulk.	Separately.	
			Lbs. Oz.	Lbs. Oz.	
115	21·9–40·6	27·7	...	59 15½	Also 1 megrim and 4 lemon dabs= 1 lb. 6½ oz.
109	21·7–38·6	...	...	...

II.—CONTRIBUTIONS TO THE LIFE-HISTORIES OF THE EDIBLE CRAB (*CANCER PAGURUS*) AND OF OTHER DECAPOD CRUSTACEA:—IMPREGNATION: SPAWNING: CASTING: DISTRIBUTION: RATE OF GROWTH. By H. CHAS. WILLIAMSON, M.A., D.Sc., Marine Laboratory, Aberdeen. (Plates I.-V.)

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In the Eighteenth Annual Report of the Fishery Board (1900) I published a paper dealing generally with the life-history of the crab. Since then I have, as occasion offered, continued my observations on this form, and on other Decapod Crustacea. Attention has been directed specially to the phenomena of Impregnation and Spawning. While the fact of the impregnation was well evidenced by the presence of the internal spermatheca liberally stocked with sperms, the exact mode in which the sperms were transferred to the female was not very apparent. With a view to elucidating the process a detailed examination has been made of the copulatory organs of the male, and the spermatheca of the female. While every stage in the process of impregnation has not yet been determined, still a considerable advance towards the full description of it has been attained.

In connection with the spawning of the higher Crustacea the attachment of the eggs to the endopodite branches of the pleopods has been variously described. The secret of the attachment has been ascribed to various agencies, the principal of which has been the assistance of a strong cement which glued the eggs to the hairs. This I have been able to show is not the case. The stalk of the egg is really formed by the

* "Contributions to the Life-History of the Edible Crab (*Cancer pagurus*)."
Eighteenth Annual Report of the Fishery Board, Part III.

outer envelope of the egg. The chorion of the egg is pierced by a hair of the endopodite. The hair skewers the eggs on one after the other until it is filled.

Observations on the distribution of the edible crab, and additions to the list of the labelled crabs which have been recaptured, are also included in this paper.

IMPREGNATION.

The act of impregnation is not very easily studied. It takes place immediately after the female crab has cast. The conjunction of the male with the female is so close, and at the same time so readily broken, that it is not possible to follow the act completely by direct observation. The study of the anatomy of the parts, however, enables one to understand the operation in a satisfactory degree. While it is probably the case that in the *Brachyura* impregnation takes place in a similar way in each species, still the great variety in the form of the intromittent organ,* and also of the vagina, of different species naturally infers a certain amount of dissimilarity in the details of the operation.

An attempt was made to observe the fertilisation in *Cancer pagurus*, but actual coition was not seen. The female, which had just cast, was put in beside a hard male crab. The female was so soft that it yielded to the pressure of the fingers in every part. It lay a plump, almost inert mass when it was withdrawn from the water. The male was in a box a little more than 1 ft. cube. The female was introduced at the corner farthest away from it. The female immediately made its way towards the male, and when it came within reach of its chelæ it remained perfectly still: the male then gathered the female up with its legs and tucked her underneath him. Sometimes the female was right side up, at another she was turned upside down beneath the male. In the case of *Carcinus maenas*, the male, on seizing hold of the female, immediately introduces its penes into the vulvæ. This did not happen in the case of *Cancer pagurus*. This species appeared less at home in the boxes: the quantity of light was probably too great. The male and the female were accustomed to lie perfectly still. The former does not injure the female except by accident, as for example when it is interfered with. The crab is extremely quick in noticing a shadow cast on the water, and throws its chelæ wildly about to find the foe whose presence has been thus heralded. On one occasion, when the two crabs had been separated in order to be examined, the male on being released blindly striking out seized the chela of the female and destroyed the limb. Impregnation was effected in the case of the crabs (*C. pagurus*) in the Laboratory, but probably at night, as it was not observed.

The male sexual organ consists of three parts. First, the genital papilla (fig. 47), which contains the external opening of the *vas deferens*, *v.d.*; second and third, the appendages of the first and second abdominal segments. Each of these organs is paired, so that there is a double male organ, consisting of three parts. The female genital organs are also paired.

The genital papilla (*g.p.*, figs. 39, 41, 47) is situated on the coxopodite of the fifth pereopod.† The *vas deferens* issues through a hole (*o.*, fig. 55a) in the coxopodite, and is protected externally by the wide sac-like genital papilla, the wall of which is strong though soft. The papilla is capable of distension, and in the living crab is usually turgid. This condition appears to be due to the introduction of fluid into the space surrounding

* Brocchi.

† Cf. Grobben and Brocchi.

the *vas deferens*. The hole in the coxopodite round which the base of the papilla is attached is situated close to the proximal edge of the bone, and when the limb is drawn forward the base of the papilla is pressed up against the edge of the sternum of the thorax (*c.p.*, figs. 39 and 41). The effect of this is to render the papilla more tense and erect. The outer skin is invaginated into the end of the *vas deferens*. Within the papilla there is on the *vas deferens* a valve (*v.*, fig. 47) surrounded by a white mass, probably muscular. The genital papilla has been termed the penis (Duvernoy*). It is not the penis in *Cancer pagurus*; it is a physical impossibility for the genital papillæ to reach the vulvæ of the female. The sperms have to be transferred from the papilla by means of the abdominal appendages. The remaining genital organs are the abdominal appendages. They are attached to the first and second segments and are very dissimilar in form. They are in fact complementary. The first appendage is of tapering shape, and is tubular. The tube is formed by the involution of its sides. The second appendage is a long rod, bent, and jointed about the middle of its length. Different authors have ascribed different functions to these appendages. Thus they have been regarded as "exciting organs," which were introduced into the vaginæ of the female, and on being withdrawn their places were taken by the genital papillæ. Duvernoy described the first abdominal appendage as a duct for transferring the sperms from the "penis" (genital papilla) to the spermatheca; the second abdominal appendage he supposed to be a sort of strut, which rested on the thorax of the female and thus formed a sort of prop between the male and female when *in coitu*. Neither of these descriptions meets the fact. The first and second abdominal appendages together form one organ, the penis. The second or rod-like appendage is during copulation inclosed within the first penis and moves up and down in it like the plunger of a pump.

It is first necessary to describe the abdominal appendages in detail. The first appendage, which will be hereafter referred as the first penis (while the second abdominal appendage will be denominated the second penis), is the more complicated.

The First Penis.

The first segment of the abdomen bears a large chevron-shaped expansion on its ventral surface (fig. 65). This chevron is really double; a small chevron (*i.ch.*), which is united with the larger (*o.ch.*, fig. 46) posteriorly, is hid beneath the latter anteriorly. The double chevron is continued backwards on either side as a broad wing-like plate, at the end of which is attached the first penis (1 *p.*). The first penis consists of two parts, a short basal joint and a long tubular distal part (fig. 37). The basal joint consists of a peculiarly shaped bone (*b.*, figs. 58 and 59) to which is attached some loose membranous tissue. The membranous tissue is shown in the sketches by dotted areas. The involution of the two sides of the distal portion forms a single tube opening by the separation of the two sides at the top. The opening is towards the median line. Fig. 25 shows a transverse section of the first penis near the tip, with the second penis *in situ*. The outer skin of the penis is hard bony chitin, but lining the tube the inner surface is soft flexible membrane. The latter is shown in the sketches by a thick black line. Fig. 16 shows an intermediate section, and fig. 4 exhibits a transverse section near the base. It shows the sides of the penis drawn

* Duvernoy, "Fragments sur les organes de génération de divers animaux." *Mémoires de l'Académie des Sciences de l'Institut de France*, t. xxiii., p. 105, Pl. I.-IX., Paris, 1853.

apart, throwing the second penis outside, but at the same time a longitudinal septum (*m.*, figs. 37, 59, 60) has appeared which continues the tube. It is merely a continuation of the side of the penis by a soft flexible membrane instead of by the hard chitin wall. The second penis is situated behind the first, and when it is introduced into the first penis it crosses over this membrane, which yields readily to pressure. In length the membrane is short; it is united below to the basal bone and forms the tissue binding that bone on one side to the tubular part of the first penis. In fig. 10 is shown a transverse section through the base. The basal bone (*b.*, fig. 59), has a large segment cut out of it, leaving its proximal part simply a narrow rim to which the membranous septum is attached. The membrane stops just a little beyond the point where the inturned edges of the penis meet and form the tube.

The tube of the penis opens in the base on the anterior side. The posterior side of the beginning of the tube is formed by the membrane. The genital papilla is inserted in the beginning of the tube. When the second penis is in the first, its broadened base lies on the posterior surface of the basal joint. Any pressure of the second penis due to its movement is transmitted through the membrane to the genital papilla (fig. 60). Moreover, as will be shown later, the second penis moves up and down in the first in a manner similar to that of the plunger of a pump; so that sperms or spermatophores ejected from the *vas deferens* into the penis tube will be pumped up and out of it. The groups of hairs that are found on the wing of the chevron and round the basal joint act as valves or packing round and in the beginning of the tube.

The Second Penis.

The second penis is rod-like. It consists of three main parts, first an arm from the end of which the rod rises at right angles (*ar.*, figs. 65, 61, etc.). This arm, which is fused to the ventral edge of the second joint, is formed in its lower half of chitin and in its upper part of soft membrane, in figs. 65 and 68. The arm is the immovable part of the second penis. From its posterior extremity rises the movable penis. It consists of two parts, viz., a base and the rod. The base consists of two bones, *a.* and *b.*, figs. 53, 54, and 56, loosely connected together and to the proximal end of the rod with soft membrane. The largest bone is of a tooth-shape. It consists of a rather broad tooth rising from an expanded base. The other is a narrow somewhat bow-shaped bone. The loose integument between it and the other basal bone permits of the former folding over towards the latter to a considerable degree.

The proximal end of the rod is expanded and cut obliquely off (*ib.*). Distally the rod tapers, at first rapidly then gradually, up to about two-thirds of its length, where there is a joint permitting a slight amount of movement. The loose part of the rod is curved, with the convexity forward. At the joint there is on the anterior side a little tuft of long spine-like teeth (fig. 104). Above the joint the rod tapers more, and it is curved in the opposite sense to the proximal portion. The tip bears a depressed oval cap set obliquely on the end; it is fringed with teeth (fig. 105). The top of the rod is cast slightly in towards the median line.

The Muscular System.

THE ABDOMEN.—The posterior edge of the carapace has attached to its under surface on each side a membranous plate directed forward into which a muscle is inserted. This plate is attached by a strong membrane to the edge of the outer chevron, and the muscle is inserted into the posterior

edge of the epimeron. The truncated membranous tip of the first abdominal segment is attached round its sides to the inside of the carapace. The inner chevron is attached by a long jointed rod (*r.*, figs. 52 and 65) to a delicate muscle inserted on both sides of the bottom of the thoracic cavity. A small muscle arises on the under surface of the outer chevron and joins this bony rod. The outer chevron is fastened to the posterior edge of the thoracic cavity by means of a membrane attached to its anterior edge.

The muscular system of the abdomen of the Brachyura has been briefly described by Duvernoy. Fig. 52 shows a median longitudinal section of the abdomen of the male *Cancer*. Half of the abdominal muscles only are of course shown. The muscles consist of flexors and extensors. There are two very long flexors, arising on the thorax, and being inserted one into the telson, the other into the skin covering the ventral surface of the united third, fourth, and fifth joints. The abdomen is flexed or extended as a single structure. The telson has movement independent of the remainder of the abdomen; thus it may, when the abdomen is flexed on to the thorax, be bent backwards from the thorax to permit the escape of the fæces, while the abdomen itself remains fast. Between the second and third joints and between the sixth joint and telson there are pairs of muscles (a flexor and extensor on each pair). At each of these joints there is a larger movement than at the other abdominal joints. Between 1 and 2, and between 2 and 3 the action of the joint is extension and flexion: the latter joint is freer than the former and affords more extension than any of the joints: between 5 and 6 there is flexion alone practically: and between the sixth and the telson there is flexion mainly, but also extension.

FIRST PENIS.—In the first penis there is a muscle which, arising on the surface of the basal bone (*b.*) and also from the side of the tubular part, is inserted farther up the same, *mu.*, fig. 59, and 1, fig. 48. The muscle will have the effect of tending to cause the bending of the two parts of the penis towards one another. There are in addition two muscles, 2 and 3, fig. 48, which arise from the outer half of the chevron and are inserted into the basal bone. The upper muscle draws the first penis forward: the lower tends to rotate the penis.

The two sides of the double chevron are connected by membrane. The chevrons, although fixed to the first abdominal segment, are not absolutely rigid. They are elastic.

SECOND PENIS.—Just as in the first penis, there is also in the second penis a muscle connecting the terminal part with the basal joint. In this case the muscle, *mu.*, arises on the tooth-like basal bone, figs. 61 and 66, and is inserted a little way up the rod. Another muscle (*mu.*, *ib.*) is inserted into the same basal bone: it arises from the side of the fixed arm of the second penis. A third muscle arises from the downward-bent end of the arm and is inserted into a bony button-like prominence on the ventral skin of the third joint (*m.*''', fig. 46). A long muscle arising from the front of the chevron is inserted into the third joint (*m.*', *ib.*); and a broad muscle, *m.*'', that rises from the base of the fixed arm is inserted on the anterior border of the inner chevron.

The Action of the Penis.

If the genital papilla of a hard male crab is pressed spermatophores may be extruded. When the abdomen of a male crab is examined the genital papilla is sometimes found inserted into the tube of the first penis, but oftener it is lying on the posterior surface of the base of that organ. But if the first penis is drawn backwards into the position it occupies when in the vagina of the female the papilla usually slips into the tube, and if the fifth pereopod is brought forward in such a way that the

genital papilla is pressed up against the edge of the sternum the introduction is aided. The coxopodite of the fifth pereopod abuts into the narrow neck of the abdomen at the first and second segments, and the genital papilla lies just beneath the first penis.

Occasionally a male has been found in which the second penis was inside the first, but usually they are separate. When the united penes are inserted into the vaginae, the abdomen is fixed at both ends. The telson lies on the thorax of the female, and the beginning of the abdomen is fixed at its proximal end by its connection to the thorax. The first penis is then held firmly, but is capable of retraction and re-insertion. The second penis is, however, free to work up and down in the first penis quite independently of it. See figs. 44 and 45. In fig. 44, which is intended to represent the position occupied by the abdomen of the male during coition, A and B are the fixed points, B being the thorax of the female, A the carapace of the male crab. The abdomen of the female is outside and closely applied to the abdomen of the male. The drawing shows the condition in which the second penis is completely entered into the first, and its tip appears projecting outside the tip of the first. In this position it is to be noted that joints 2 and 3 are extended, i.e. the joint between them is depressed. In the drawings they are shown upside down. Now by the flexing of joints 2 and 3 the second penis is withdrawn partly from the first, while the first remains stationary (fig. 45). By each movement the second penis presses on the genital papilla, and therefore probably causes the issue of spermatophores into the tube. The efficacy of the pumping arrangement was demonstrated experimentally. A small quantity of a thin carmine paste was introduced into the bottom of the tube, and by alternately pushing in and withdrawing the second penis the carmine was pumped out at the top. By the flexion and extension of the portion of the abdomen, then, the sperms (spermatophores) would be gradually transferred to the spermatheca, into which the first penis penetrates.

The Condition of the Spermatheca.

If the soft female crab after it has been impregnated is examined, it will be found that the mouth of the spermatheca and the vagina is filled up by a large plug of white material (*pl.*, fig. 49). This plug may be usually split into two halves, as was shown in a previous paper.* The spermatheca is globular in shape and is filled with an amber-coloured fluid, and a more or less extensive white patch of sperms, situated in the proximal and external part of the organ. The top of the plug which extends just within the spermatheca is soft and pulpy, being in contact with the fluid, whereas in the vagina the plug is hard and fibrous in appearance. It has been noticed that the top of the plug has been grooved or scored as if a thin body had been repeatedly impressed in it.

In a hard female crab which has been impregnated the spermatheca is of much smaller size than in the soft crab (fig. 67). It is then flattened, shrunk, disc-shaped, and contains a quantity of sperms (*sp.*) and some amber-coloured hard material (*sl.*), which is the solidified remains of the fluid which filled the spermatheca at the time of fertilisation. The inner wall of the spermatheca (*sp.w.*) and the vagina (*v.w.*) are continuous, but that of the spermatheca is much the thinner (fig. 38).

In my previous paper on *Cancer pagurus* I stated that the inner lining of the spermatheca and the contents of the latter were thrown off with the cast integument during the moult, an opinion held also by Cano.

* "Contributions to the Life History of the Edible Crab (*Cancer pagurus*)."
Eighteenth Ann. Report of Fishery Board for Scotland, Pt. III., 1900.

This I find is not the case, with adult crabs at least. Each crab which I have examined after it had cast, and before it had been in contact with the male, was found to have a spermatheca resembling in general that of a hard crab, *i.e.*, it contained a quantity of sperms and some amber-coloured solid. If a soft crab which has been with the male, and is plugged, be dissected, no amber solid will be found in the spermatheca, and there is usually a large quantity of sperms with a large quantity of amber fluid. When does the crab get rid of the old sperms and amber solid? The inner lining of the spermatheca, although it does not come away during moulting, is nevertheless very loosely attached, and I have drawn out the inner lining and the contents of the spermatheca, along with the lining of the vagina, through the vulva, in a dead hard crab. On casting only a very little of the inner lining of the spermatheca is shed; that is, the part round the mouth.

Just inside the spermatheca the lining thins out quickly. The mouth of the spermatheca is surrounded by a sphincter muscle, *mu.*, fig. 38.

The break between the lining of the vagina and that of the spermatheca takes place near the point where the thick layer of the vagina thins down to that of the spermatheca (fig. 38). In the newly cast crab, moreover, there was no fluid in the spermatheca. The spermatheca of the crab has a glandular secreting surface. It is probably the case that the secretion of the fluid causes the loosening of the inner layer, and on the introduction of the penis the amber solid and the old sperms may be expelled with the outflow of fluid. The secretion of fluid in the spermatheca is possibly stimulated by the presence of the male. The vulvæ are always tightly closed except when they are kept open by the plugs. On the introduction of the penis the fluid will flow out round it in the vagina and will prevent the entrance of sea-water into the spermatheca. *Vide* diagram, fig. 55. This fluid coagulates with sea-water, forming a whitish precipitate. The plug in the vagina is of a hard fibrous structure and of white colour. During the time the male and female are in conjunction, a period of probably several days, the piston-action of the second penis would transfer the sperms to the spermatheca. The crab, then, on casting does not get rid of the remains of the old stock of sperms until it has the opportunity of being impregnated afresh.

Some experiments were made with certain crabs which cast during 1902, August 31st to October 15th, and the results are of interest. A female, measuring $5\frac{3}{4}$ inches across, was put with the male crab as soon as it was seen to have cast, and four days later pieces of plug were seen projecting from the vulvæ. Another measuring 5 inches was separate from the male two days after, and at that time a plug projected from the vulva. A female crab, measuring $6\frac{3}{8}$ inches across, was kept for four days after casting. It was not in contact with a male crab. It was then killed: no fluid was found in the spermatheca. Six days after casting the soft crab which measured $6\frac{1}{16}$ inches across, and which had not been in contact with a male crab, was dissected. The spermatheca contained sperms and a row of hard amber-coloured solid. A small soft crab, *viz.* $4\frac{1}{8}$ inches across, was put with a male crab. Twenty-four hours after, no plugs were seen, but they were visible two days after the introduction of the female.

It is to be noted that while in the male crab the sperms are contained in spermatophores, in the spermatheca the sperms are loose; in very few cases was a spermatophore seen. According to Duvernoy, sea-water causes the spermatophores to burst.

The extrusion of the spermatophores from the *vas deferens* is no doubt aided or effected by the following circumstances. The *vas deferens* of the hard male crab is usually in a swollen condition, and therefore the

opening of the valve in the genital papilla would immediately be followed by a free issue of spermatophores. The opening of the valve may be due to the pressure of the second penis as it moves in the first, aided possibly by the forward movement of the fifth pereopod, which will result in increasing the turgidity of the papilla.

A portion of white plug material has been found on the penis in more than one crab. One case calls for special mention.

A large male crab, 6 inches across, hard, was examined at the beginning of June. The second penis was inside the first, the genital papilla was inserted into the beginning of the tube. Projecting from the aperture in the tip of the first penis there was a narrow rod-like white body. At the inner side of the base of the first penis there was a small white mass. On examining the rod with the microscope it was found to be a tube crammed with spermatophores; on its outer surface there were sperms and spermatophores. The tube was formed of parallel fibres. It was found in one penis only. No spermatophores were found in the lower white mass, which had the same fibrous appearance that the plug has. In no case were spermatophores found in the spermatheca packed in a tube. The tube, if it is the normal condition, may act simply as a sheath inside of which the spermatophores travel. It is formed simply by the introduction by the base of the penis of some of the fluid of the spermatheca which had flowed out from the vagina. By working the second penis in piston-fashion the tube was gradually pushed out of the first penis. It had apparently been connected to the white mass at the base.

THE IMPREGNATION OF *CARCINUS MÆNAS*.

The structure of the intromittent organs and of the spermatheca differs considerably from those of *Cancer pagurus*. It is not, however, proposed to deal with these differences, but to describe the act of fertilisation so far as it was possible to follow it with the naked eye. It is not likely to be strictly homologous to that in *Cancer*.

Carcinus mænas is not apparently incommoded to any considerable extent by captivity, and it is possible to observe the act of impregnation. In the following case the male was put into a glass jar, and a female which had cast the previous night was then introduced beside it (September 16th). The male immediately turned the female, with the assistance of the latter, upside down. The female raised (or extended) its abdomen and brought it outside the abdomen of the male. The male then extended its abdomen, and rested its telson (bent at right angles to the abdomen) on the thorax of the female between the vulvæ, immediately thereafter inserting its penes into the two apertures. These operations took place in a few moments. The male then pushed the penes into the vaginæ and drew them out slightly, about once every two seconds, but while under observation intermittently. The male carries the female about with it, and the female is attached to the male simply by the hooked penes. The legs of neither crab are used for attachment. The penis appears to be inserted only a short distance.

On September 18th the two crabs were still *in coitu*, but on the 20th they were separate.

The female was now fairly hard. It was killed on the 20th.

There were no externally projecting plugs. The spermatheca was filled with a large irregular plug which projected a little way into the vagina. In the vagina from the end of the plug just mentioned to the vulva there was another short plug with a rounded upper extremity; along its length it showed a slight groove. Round the external end of the spermatheca and along the vagina there is a layer of gelatinous-like tissue,

probably glandular. Some spermatophores were found on the plug inside the spermatheca. In the vagina of the other side the short plug was absent.

A female which cast between the 22nd and 23rd October, and which had not been in contact with a male, was dissected on the latter date. It was already fairly hard, the integument resembling in feel stiffish brown paper. The spermatheca was large, with thick walls; it had a little white mass at its mouth. There was a certain amount of fluid in both spermathecæ, but the latter were not globular.

THE SPAWNING OF *CANCER PAGURUS*.

The Mode of Attachment of the Eggs to the Swimmerets.

The external eggs of the edible crab are, like those of other decapod crustacea, carried, during incubation, on the hairs of the inner branches of the swimmerets of the female. They are arranged on the hairs from their bases to the tips as thickly as they can lie. When the hair of a berried crab is examined, a condition similar to that shown in fig. 21 is seen. The eggs are attached by independent stalks to the hair, and they are moreover so closely set together that their stalks intertwine. As, however, the egg is not always attached to one hair alone, but sometimes to two, we have the hairs grouped in bunches which correspond to their whorl arrangement on the endopodite, *e.g.*, *cf.* fig. 26. The intertwining of the stalks of eggs also tends to bind the hairs together.

How do the eggs become attached so closely and regularly and in a manner so economical of the space at their disposal?

Several agencies have been invoked to explain this. Cano* and Herrick† have each given an historical resumé of the theories held with regard to the mode in which the attachment of the eggs to the pleopods was brought about. It is not necessary to recapitulate it nor Cano's full discussion of the egg-membranes of the decapods. According to Lereboullet‡ certain zoologists had explained the attachment of the ova to an extension of the primary egg-membrane.

There has, however, been general agreement that the fixation of the egg is due to a cement with which it is coated; that the egg becomes in one way or another covered with a cement which on exposure to seawater hardens, after having glued the egg to the hair of a pleopod. The cement was supposed to be derived from the ovary or oviduct by Milne Edwards and Rathke; from the spermatheca by Cavolini and Cano,§ and in the case of *Astacus* from the integumental glands found on the pleopods and ventrum of the abdomen by Lereboullet and Braun.

While in the case of macrurous decapods this explanation might not be dismissed on *a priori* grounds, it is impossible to accept it as applicable to the Brachyura. It matters not how the cement is produced, the question reduces itself to this position—Given an egg coated with a cement strong enough to form the stalk of the egg, which resists rupture for a period of eight or nine months, a period during which time the swimmerets are being continually agitated in order to aerate the eggs, is it at all likely that it would always attach itself to a hair, and never to another egg similarly coated? If we examine the eggs of a *Cancer*

* Cano, "Morfologia dell' apparecchio sessuale femminile, glandole del cemento, e fecondazione nei Crostacei Decapodi." *Mittheil. Zool. Stat. zu Neapel*, ix. Bd., 4 Heft., 1890.

† "The American Lobster." *Bull. U.S. Fish Commission* for 1895, p. 127.

‡ Herrick, "The American Lobster." *Bull. U.S. Fish Commission* for 1895.

§ Cano, *op. cit.*

pagurus, *Carcinus menas*, *Portunus* sp., *Hyas* sp., etc., we will find the eggs attached by their long stalks to the hairs of the endopodites. They are closely set together, but in no case do we find two eggs stuck together. If the eggs had been coated with cement, they could not have avoided sticking together, and also to the exopodites. What special affinity can there be between the cement and the hair which does not exist between the cement of two eggs? If the cement on being acted upon by seawater hardened, what is to prevent the two eggs from sticking together? When the eggs are extruded they lie in the incubatory chamber formed by the curved abdomen in a semi-fluid mass, and they are there retained by the overlapping exopodites. The latter prevent the eggs flowing out over the edge of the abdomen. Now if each egg were coated with a layer of cement, we should have the eggs concreted into a solid mass, and while the endopodites would be imbedded in it, the exopodites would be probably glued to the outside. The eggs never attach themselves to the exopodites with which they are in close contact.

No cement is supplied by the spermatheca. When the eggs are extruded the spermatheca is dry except for the pasty white mass of sperms; the solid remains of the spermatheca fluid are present. This solid is the consolidated residue of the fluid which was secreted by the spermatheca just after the crab cast and when it was impregnated. Cano evidently supposed that the cement was secreted by the spermatheca.

The egg does not derive a coating of cement from the ovary. The ripe eggs, if taken out of the ovary, sometimes have a slight coating of an albuminous substance; it is derived from the yolk of ruptured eggs, which is somewhat sticky, for by it an egg may become attached to the bottom of the vessel in which it is; but the union is of the slightest, and a touch from a camel-hair brush is enough to dislodge the egg. That the attachment does not result from an external coating of cement is therefore apparent.

An opportunity which I had of observing the spawning of *Cancer pagurus* has enabled me to describe the manner in which the attachment of the eggs is effected. The fact that the eggs are attached to the hairs of the endopodite, which are smooth, and not to the hairs of the exopodite, which are plumose, necessitates a condition in which an attraction or affinity exists between the egg and the endopodite hair which does not exist between it and the exopodite hair.

The conditions which are necessary to the regular attachment of the eggs to the hairs of the endopodite, and to them alone, are the following—(1) the eggs themselves must not be coated with a fluid which is of itself sufficient to cause it to adhere to anything when it is extruded, or otherwise we should have the eggs adhering to one another; (2) the hairs must not likewise be coated with an adhesive cement, or they also would be glued together; (3) after extrusion a condition must arise which will lead to the attachment of the eggs to the hairs of the pleopods, and the relation is one which acts between each egg and some particular hair.

The intimate relationship between the egg and the hair is due to the hair acting as a skewer upon which the eggs are impaled and strung.

On extrusion the ripe egg has two investing membranes, the outer or chorion and the very delicate vitelline membrane, the "dotterhaut" of Rathke. The hair perforates the chorion and enters the "perivitelline chamber," and passes out again without piercing the vitelline membrane which is so closely applied to the yolk-sphere, and is moreover so delicate that it is not readily recognised. The process is more easily followed when the structure of the abdominal appendages is examined.

The endopodite and exopodite of the pleopod are very different from one another, and their different functions are very evident from a minute examination of their forms. They will therefore be described below in detail.

In addition to the discussion of this question in the case of *Cancer pagurus*, observations on the spawning of *Carcinus maenas*, and on the manner of egg-attachment in *Homarus*, *Nephrops*, *Munida*, and other forms, will be added.

The Swimmerets.

There are four pairs of swimmerets, attached to the second, third, fourth, and fifth abdominal joints respectively, fig. 15. Each consists of an outer, the exopodite (*ex.*), and an inner branch, the endopodite (*en.*).

The description of the swimmeret of *Carcinus maenas* by M'Intosh* applies very well to *Cancer pagurus*:—"First pair of Abdominal Feet.—The internal limb [endopodite] is clothed for the most part with long, delicate, silky hairs, which are simple throughout, with the exception of some branched hairs at the base, best seen on the anterior surface of the foremost limb. The former are pale and translucent, and come off in distinct bundles all the way up from their commencement. The tufts above the middle joint arise from the upper part of each of the pseudo-joints that compose the flabellar extremity, being situated, likewise, only on the posterior surface and sides of the limb, the anterior surface being free. The hairs themselves are very beautiful, presenting externally a brownish or yellow outline, within this a pale streak, and then a more or less granular central portion . . . The external limb is covered with branched hairs from base to apex along both outer and inner edges, the hairs on the outer row being rather longer than those on the inner. A few short, smooth bristles are distributed over the general surface of the limb." "The ova, when present, are attached solely to the inner limb of each abdominal appendage."

The Endopodite.

The endopodite (*Cancer pagurus*) is long, cylindrical, tapering to a blunt point; it is bent slightly in bow-shape, the concavity being towards the anterior side. Over its whole length it bears transverse rows of long, stiff, slender hairs. These rows are not set at right angles to the long axis of the endopodite, but run obliquely downwards from the inner (next the median line of the abdomen) to the outer edge, *en.*, fig. 20a. They are moreover confined to the posterior surface, their ends appearing at the edges only of the anterior surface. On the outer edge they come a little further on to the anterior surface than on the inner side, *en.*, fig. 20b, and fig. 63, which gives a plan of one of the rows. The tips of the two endopodites of opposite sides meet in the middle line, and the hairs on their inner surfaces are together bent forwards, fig. 13. The hairs are thus pointed in every direction. The arrangement of the hairs on the posterior surface of the tip is shown in fig. 62.

The hairs from their extreme thinness are very flexible. They are perfectly smooth, except near the tip. The latter ends in a sharp process, and close to the extremity of the hair there are a number of delicate cilia (fig. 23a). The tips of the hairs do not all conform to this type. Considerable diversity of structure was found in different hairs, *vid.* figs. 22, 23, 31, 33; they usually, however, end in a more or less acute point, and the cilia are generally to be made out. It is probable

* M'Intosh, "On the Hairs of *Carcinus maenas*." *Trans. Linn. Socy.*, vol. xxiv., p. 97.

that the variations are due to the delicate terminal spine being broken off, and the different conditions noted and drawn in the figures may be stages in the regeneration of the extremities of the hairs. This repair would appear to be continuous.

The hair is tubular, and in the central cavity or core there is a large quantity of minute oval corpuscles.

The shell of the hair consists of two main thick layers, viz., an outer, *o.l.*, and an inner, *i.l.*, figs. 30 and 32. They are laminated in structure; the outer layer shows a division into one, sometimes two, thin cuticular layers; and the inner layer usually shows a separation into one thin layer on the outer side, and sometimes also a thin layer next the core. The internal surface of the inner layer is uneven, corrugated in appearance. The inner layer varies in thickness in different parts of the hair: at the base it is especially thick, fig. 30. It is practically a replica of the outer layer. The two layers are to some extent independent, or at least separate easily from one another. This is seen when a hair is broken. It often happens that when the outer layer is snapped, the inner layer remains intact, and the two parts of the outer layer become separated by an interval, *vid.* fig. 6. It does not appear that the separation of the broken halves of the outer skin is due wholly to a sliding over the inner, but rather also to the fact that the inner layer expands on the release afforded by the rupture of the former.

The anterior surface of the endopodite has scattered over it short, stiff hairs, fig. 50.

The endopodite is jointed at about a fourth of its length from the base, and at this point there are muscles for moving the distal portion. The latter bears the greater mass of the hairs.

The Exopodite.

The exopodite resembles somewhat the endopodite in form. It is, however, more flattened in its proximal part than the latter. With the exception of the fourth, the exopodites are more or less twisted on their axes in such a way that the edges bearing the hairs are brought into an obliquely antero-posterior position, *vid.* fig. 13.

The exopodite is furnished on either side from base to tip with a very thickly set row of plumose hairs. These are of various length, *vid.* figs. 11, 12, 35, and 36. In the case of the shortest hairs, the ciliation commences close to the base, while in the others it begins further along the stem in proportion to the length. In the case of the longest hairs almost the whole of the proximal half is bare of cilia, fig. 36. Through the closely set arrangement of the hairs of different lengths, the short hairs supply the ciliation which is absent from the stems of the long hairs. In this way there results the formation of a thickly-set hedge, with no unnecessary overlapping of structures. The ciliation is at first sparse, but quickly increases in amount.

The cilia are all long, stiff, terminating in fine points; they are moreover serrated. On the shortest hairs they are long and slender, fig. 8; on the longer hairs flattened, lanceolate in shape, fig. 7. They are arranged all round the stem of the hair, recalling generally the structure of a test-tube brush. At the extremity of the hair, in consequence of the shortening of the nodes, the cilia are packed closely together round the falcate tip.

The stem of the hair is tubular. The core is narrow, the wall thick and composed of several layers, fig. 9. Fig. 17 shows an ocular section at the base of the hair. The tube of the hair is continuous with a canal in the exopodite.

The plumose hairs are not confined to the two edges of the exopodite, but are also found on the outer surface, *vid.* fig. 42. They do not, however, run round the stem in rows as do the hairs of the endopodite; they are simply scattered over the outer surface.

The inner surface of the exopodite, fig. 51, is provided with scattered short hairs, which are serrated.

The Ripe Egg.

The eggs of *Cancer pagurus* are ripe during October, November, December, and January,* and spawning may take place in each of these months. The eggs are extruded in a short space of time, probably within a period of twenty-four hours.

In my former paper, "Contributions to the Life-History of the Edible Crab (*Cancer pagurus*)," I described the ripe ovary as follows:—"The ripe ovary is of a turkey-red colour. . . . All the eggs are not of one size. The diameter of the yolk-mass may vary from .3—.41 mm.; in some eggs the yolk-sphere is as small as .24 mm. The diameter of the *Zona radiata* varies greatly from the fact that the egg in the ovary has a large perivitelline space. . . . The diameter of the capsule may vary from .4—.7 mm.; the eggs attached to the swimmerets measure .45 and .5 mm. in diameter." I have, however, come to the conclusion that the condition just described, where the ovarian egg shows a large perivitelline space, is a pathological one. I have since then only found it in crabs that died during the spawning season; the dropsical condition of the ovary having possibly been the cause.

The ripe ovary, however, sometimes exhibits a condition which suggests the presence in it of eggs with large perivitelline space. In a crab measuring $7\frac{1}{8}$ inches across (17 November, 1903) the ovary was full and of a crimson-red colour. When its outer surface was examined with a lens, a clear area was seen surrounding the egg. This clear area is a sort of fluid space in the follicle, and is not a perivitelline space; it is outside the egg.

The ripe egg has *two* envelopes—the inner, the vitelline membrane (*v.m.*), is clearly applied to the yolk-sphere; the outer, the chorion (*chr.*), is separated from the former by a very narrow space when the egg is *in ovario*. Fig 5 shows a section of the ripe ovarian egg. It is contained in the follicle (*f.*). The yolk-sphere is composed of large corpuscles. Mayer† was of the opinion that fertilisation took place in the ovary before the egg was invested with the chorion.

Rathke‡ described, on the egg of *Astacus*, *three* egg-membranes, viz. "die Dotterhaut" [the vitelline membrane], "die Lederhaut," and "die aussere Eihaut" [the chorion]. In the egg, previous to the commencement of the development of the embryo, there is a space between the "Dotterhaut" and the "Lederhaut," which contains a transparent fluid; the quantity of this fluid diminishes as the development proceeds. In this way the "Dotterhaut" and the "Lederhaut" come to lie closely together. The "aussere Eihaut" is that by which the egg is attached to the swimmeret. This description does not apply to *Cancer pagurus*, where there are only *two* egg-membranes.

A section of a dropsical ovarian egg is seen in fig. 34. These eggs can be made out with the naked eye scattered over the surface of a lobule of the ovary when few in number; when the majority of the eggs are

* Heath's observations lead to a similar spawning-period for *Cancer magister* on the coast of California. *American Naturalist*, 1902.

† P. Mayer, *Jena. Zeit. Naturwissen*, 11 Bd., 1877.

‡ Rathke,

thus distended the ovary is swollen and contains a considerable quantity of an amber-coloured albuminous fluid. In the dropsical ovarian egg the perivitelline space is filled with an amber-coloured fluid, which is somewhat granular in appearance. Some of the eggs had been preserved in a one per cent. solution of formaldehyde in sea-water, and the perivitelline fluid was found to have solidified into a whitish substance resembling coagulated albumen. This substance cut easily, being of a cheese-like consistency, and it formed round the yolk-sphere a thick rind which could be removed in two hollow hemispheres. The dropsical eggs when fresh are rather dull in colour, in contrast to the bright normal egg.

The ovarian eggs, and also those which are lying on the abdomen of the crab before they become attached to the swimmerets, show under the microscope no trace of cement on the outside; the chorion shows a sharp clean surface. If the ripe eggs be taken from the ovary and put into sea-water a perivitelline space of more or less extent begins soon to appear. The egg imbibes water, and the chorion or outer envelope is distended, and stands out all round clear of the inner, the vitelline membrane (*vide* fig. 95).

Certain ripe eggs were extracted from the vagina of a female that had been spawning, by means of a pipette introduced by the vulva. They were practically identical with the ovarian egg, there being practically no perivitelline space (fig. 94).

If the eggs which have been extruded, and which are found in a semi-fluid mass lying on the abdomen of the crab, be examined, some will be found to be attached to the hairs, while others are loose. The latter show large perivitelline spaces, but not so large as in the dropsical eggs. A large quantity of eggs which had been extruded a week previously, and which had not become attached, but were lying in a heap in a corner of a box in which a spawning female was confined, had very large perivitelline spaces; they were stuck together, but were easily separated.

The essential for the attachment of the egg to the hair of the endopodite is the large perivitelline space, to which the great ductility of the chorion contributes materially. In each of the eggs, from that showing practically no perivitelline space, viz. the ovarian egg, to the egg which has been a considerable time in water and in which the perivitelline space has reached enormous dimensions (fig. 96), the chorion always shows a sharp definite outline without wrinkles, *i.e.*, as long as the chorion is unpierced by the hair.

Certain experiments bearing on the formation of the perivitelline space were made on the eggs from apparently ripe ovaries during November. A portion of the ovary was teased out in sea-water. It is to be noted that the space does not begin to form in all cases—and even if it does form it may be only slight in extent—although the eggs may be indistinguishable from others which do so. Whenever the vitelline membrane is ruptured (as may often happen in teasing the ovary), the egg immediately forms a large perivitelline space, and the fluid in the latter becomes amber-coloured or pinkish, whereas in the normal egg it is colourless.

On November 17 a female measuring $7\frac{1}{2}$ inches across was dissected. The ovary was friable, and the eggs, which measured $\cdot 37$ and $\cdot 4$ mm. in diameter, separated out easily in water. There was no perivitelline space visible. At the end of three minutes a distinct perivitelline space had appeared.

In another crab the ovary was full and of a crimson-red colour. After being in sea-water for about an hour the eggs showed perivitelline spaces of considerable amount.

A crab measuring $7\frac{1}{2}$ inches across on November 9th had an ovary

which was large and full. The eggs measured about .4 mm. in diameter. Some were a little less; others larger and narrower. Certain of the eggs were put into fresh water: others into sea-water. They began to form spaces in a few minutes. In the fresh water the eggs which had been of a bright red colour imbibed the water so much that the inner egg (yolk-sphere) became disorganised, and the fluid in the space became red or amber-coloured. The whole egg, moreover, became whitish-pink to the naked eye—the condition seen in dead eggs. A considerable perivitelline space formed in the eggs in the sea-water in about ten minutes, and the eggs were not disorganised.

The rapidity with which the perivitelline space is formed depends on the stage of development of the egg. Minute differences occur between eggs of an apparently similar stage of ripeness.

In another case the eggs were examined twenty minutes after they were put into sea-water, and they then showed perivitelline spaces. Several days afterwards, the perivitelline spaces had increased in extent, but the eggs retained the fresh normal colour.

In none of the experiments did any of the eggs stick to the glass.

On October 30th a crab was found to have spawned, probably during the preceding twenty-four hours. A large quantity of eggs was lying in a heap on the bottom of the tank, while a large amount of eggs was contained on the abdomen. Some of the hairs of one of the endopodites were snipped off, and on examination the attached eggs showed an early condition of the process of attachment. In some the zona was not yet completely collapsed: some of the eggs were however already stalked. There was a number of dead eggs attached to the hairs. On one of the hairs the little cilia were seen to be turned back, as if they had been bent over as the hair was pushed through the egg membrane. The eggs that were lying on the bottom of the box were quite separate, and they showed under the microscope no coating of cement, as did neither of the ovarian or attached eggs.

An experiment was made with the view of testing whether or not the perivitelline fluid had adhesive properties: this fluid was found to be sticky. Some ripe eggs were put into sea-water and left there until the perivitelline spaces were well developed. Four of these were transferred to a watch-glass. The chorion of one egg was pierced by means of a needle, and the egg began immediately to show an adhesive property. Under the microscope a slightly refractive fluid was seen to have flowed out of the puncture and to have stuck to the glass. On the following day the egg was attached to the glass, while the others were freely movable. It was, however, detached by a puff of sea-water from a pipette, although it resisted gentle suction by the same instrument.

The egg then having the large perivitelline space is pierced by and skewered on to an endopodite-hair. The chorion collapses, and being extremely delicate falls round the hair clinging to it. The perivitelline fluid being somewhat sticky no doubt helps to glue the chorion to the vitelline membrane, to other parts of the chorion, and to the hair.

The eggs which escaped piercing, and which lay on the bottom of the box, showed large perivitelline spaces: they grow dull in colour and die. It is probable that the pressure set up within the chorion by the osmosis is sufficient to cause the death of the egg, unless it is relieved by the piercing of the membrane.

In certain ovaries degenerating eggs were found. They were usually of a dull pink colour, and their contents were disorganised. The ovaries were sometimes full of these eggs, *e.g.*, in some of the crabs kept in confinement—spawning having in some way been prevented.

The Attachment of the Eggs.

On being expelled from the ovary the eggs are received into the so-called "incubatory chamber" formed by the curved abdomen. The perivitelline space rapidly develops in each egg. The abdomen is withdrawn from the thorax, and the sixth abdominal joint and the telson are turned upwards, giving a quadrant shape to a longitudinal section of the abdomen, *ab.*, fig. 14. The thorax forms the anterior end, the abdomen the floor and posterior end of the chamber. The two sides are formed by the exopodites, which by means of their plumose edges overlap and prevent the eggs flowing out over the edge of the abdomen. The condition is shown semi-diagrammatically in fig. 19. The eggs are apparently extruded continuously until all are expelled. They then lie in a semi-fluid mass in the "chamber," and embedded in the mass of eggs are the endopodites with the flexible sharp-pointed hairs. The endopodites have, independently of the exopodites, two distinct movements, of small extent, one in an antero-posterior plane, viz., *a.—a.*, fig. 19, and the other in an oblique direction across the abdomen, indicated by the arrow, *p. — p.*, and *p.'—p.'*; *p.—p.* referring to the endopodites of the right side, *p.'—p.'* to the endopodites of the left side. This oblique motion belongs to the distal parts of the jointed endopodites. The hairs reach every portion of the receptacle. The continued double movement of the sharp slender hairs through the mass of eggs confined in the incubatory chamber results in the eggs being impaled and thickly skewered on to the hairs. This condition is shown in fig. 1, which represents a hair taken from a crab which had extruded its eggs only a short time, probably not more than twenty-four hours, previously. In the drawing the perforations in the zona are exaggerated. The hair avoids piercing the yolk, simply passing through the zona into the perivitelline space, and then issuing at a place near the point of entrance. Some dead eggs which were being devoured by Nematodes and Acarinæ were found on the hairs. How far the death of the eggs was due to the accidental piercing of the yolk by the hair, or to the unfavourable conditions under which the crab was living at the time (viz., in confinement in a small hatching-box), is open to question. The hair on striking and entering the zona will almost of necessity force the egg to turn round in such a way as to bring the yolk-sphere off the line of impact. The yolk-sphere would naturally tend to keep at the lower pole of the egg.

In a short time the zona collapses, and it becomes glued to the hair by means of the perivitelline albuminous fluid. The stalk or pedicle is formed by the adhesion together of the parts of the zona which meet. This condition was found when the eggs were examined twelve days later. Figs. 3*a*, 3*b*, 3*c*. An interval of that duration is, however, possibly not necessary for this change to occur. The stalks vary in breadth, and they are now more or less wrapped round the hair. All the crabs under observation threw off their eggs shortly afterwards, but in a crab which had spawned in a tank, and which was examined in January, the stalks were now found to be rope-like in many cases. The stalks of the eggs were also intertwined. The movement of the swimmerets, which is probably continuous in order to afford aeration to the eggs, will, by tending to throw the yolk-sphere as far away as possible from the point of attachment, result in the formation of the long rope-like stalk, fig. 21.

Some of the eggs are pierced by two hairs, and through this it happens that the hairs are bunched together. This takes place not only with the hairs of one row, but also with the hairs of adjacent rows. The grouping of the hairs is, however, no doubt mainly due to the interlocking of the eggs attached to different hairs.

Sometimes a hair is seen to be fixed in a position in which it is bent double.

The egg in the condition last described, firmly attached to the hair, is seen on sectioning (figs. 18a and 18b) to have three layers, which are the three layers noticed by Rathke in the egg of *Astacus*, but this author regarded the outer investment ("Aussere Eihaut") (the chorion) as derived from the "cement." The three layers of the egg-shell are, (1) outermost, the chorion (*chr.*); (2) next the yolk, the delicate vitelline membrane, *m.* ("Dotterhaut"); and between the two a thicker layer which appears to have been formed simply by the solidification of the perivitelline fluid, *sl.*, figs. 18a and 18b ("Lederhaut"). This results in gluing the two primary layers together, in that way forming an efficient protecting envelope to the egg.

The Sloughing of the Empty Egg-Capsules.

A point of some interest is the manner in which the crab gets rid of the empty egg-capsules after the hatching of the brood. This is effected by sloughing off the outer layer (*o.l.*, fig. 32) of the wall of the hair along with the attached capsules, fig. 43. The slough of the hair is shown of greater diameter than it ought to be in proportion to the rest of the figure.

The minute oval corpuscles found in the cavity of the hair probably function in forming a new inner layer of the hair, and in repairing injuries which the hair may receive.

THE ATTACHMENT OF THE EGGS IN OTHER DECAPOD CRUSTACEA.

A number of species have been examined with a view to determining whether or not the condition of the attached eggs was such as would lead one to infer that the mode observed in the case of *Cancer pagurus* was a general one or not.

The spawning of *Carcinus maenas* was observed, and it will be treated below. In the following species of Brachyura and Anomura the berried females were examined, viz., *Maia squinado*, *Portunus* sp., *Hyas* sp., *Stenorhynchus* sp., *Eupagurus* sp., *Lithodes maia*. In these the condition of the endopodite and the attached eggs was similar to that of *Cancer pagurus*, and the mode by which the eggs become attached is the same.

In *Maia squinado* ($4\frac{1}{2}$ inches across the greatest breadth of the carapace) the spermatheca is very large, and it differs much from that of *Cancer*. In the latter the solidified remains of the fluid secreted by the spermatheca are got rid of at the next impregnation; in the former they are retained, and as a fresh secretion of fluid takes place with each impregnation the spermatheca attains enormous dimensions.

The berried females of certain Galatheidæ and Macrura were also examined, and the details will be given below.

In the Macrura the pleopods differ much from those of the Brachyura. In some cases the exopodites afford attachment to the eggs, while also hairs on the sternum of the abdomen attach to themselves eggs. Both branches are more or less thickly furnished with densely plumose setæ which function for swimming. The egg-hairs, usually ciliated in part, are short, and so there are not many eggs on one hair. The eggs are in large measure attached to the protopodite of the pleopod. The conclusion reached with regard to these also was that the attachment of the egg was effected through the piercing of the chorion by the egg-hair.

Munida rugosa.—The eggs are much larger than those of *Cancer*.

The pleopod has no exopodite; it consists of a single-jointed protopodite and a 2-jointed endopodite. The endopodite is furnished with a great quantity of fine egg-hairs (fig. 27).

The eggs have very long stalks and are not arranged along the hairs as in *Cancer*, but the tips of one or of many hairs are inserted into the stalk of the egg; and they sometimes pass up the stalk for a considerable distance (figs. 28 and 29). In this case, then, there is never more than one egg to each hair, but very often only one egg to a group of hairs. Its position on the extremity of the hair gives occasion to much rotary movement of the egg, and through this the stalk becomes tightly twisted like a rope.

Some of the hairs of this species are setose over the whole of their length, the cilia being long: the extremity of the hair is bare for a greater or shorter distance. The short egg-hairs are setose on the middle of their length (fig. 27). The cilia are longer at the distal end and become less as they are more proximal. This probably prevents the hair entering the egg very far on its piercing the chorion.

Galathea dispersa.—In this form there does not appear to be more than one egg to each hair; and a group of hairs sometimes enters one-egg stalk. A cluster of eggs is sometimes found on one fascicle of hairs.

A condition similar to *Galathea dispersa* is apparently present in *Calocaris macandrea*.

Homarus vulgaris.—The pleopod is short and paddle-like. The endopodite is 2-jointed. The two branches are provided with the usual setose hairs round their margins, and on the posterior or concave surface of the endopodite there are arranged round the margin the egg-hairs. They are not nearly so numerous as the plumose setæ. On the exopodite at its basal outer corner there is a fascicle of egg-hairs. There are several fascicles of the same on the protopodite and also on the sternum of the abdominal segment.

The egg-hairs are extremely delicate. The tips only are ciliated, and the cilia are directed forward along the extremity of the hair (fig. 58).

The eggs are not attached to the distal parts of the endopodite and exopodite. In this form they are attached in two ways—(1) by the usual stalk attachment to the hair, a condition brought about in a way similar to that of *Cancer*; (2) eggs are attached to one another by stalks and without the intermediary of an egg-hair, *vide* figs. 56 and 57. The stalks which these eggs show, and which may be two or three in number, exactly resemble the stalks of the eggs attached to hairs; they are without doubt formed by the chorion. In no case were two eggs found to be sticking together in the way in which the demersal eggs of a fish, *e.g.* *Cyclopterus lumpus*, stick together. In the latter case the two eggs form at the point where they are glued together a flat common wall. In the lobster, on the other hand, the eggs are all stalked, and the fact that each egg usually has more than one stalk gives some apparent ground for the theory of the cement-covering of the egg.

Scott* has recently described the spawning of the lobster. The female lay on its back, and the eggs flowed down into the incubatory chamber formed by the flexed abdomen. When the eggs, just after they emerged from the genital openings, were placed in a glass of sea-water and collected into a heap they all became attached one to the other, "and also to the glass. Moreover, the adhesive material only remains soft for a short time, as when the individual eggs were isolated and prevented from adhering to the glass it was found that at the end of half-an-hour

* Scott, "On the Spawning of the Lobster." *Report of the Lancashire Sea-Fisheries Laboratory for 1902*. No. xi. Liverpool, 1903, pp. 20 *et seq.*

the adhesive property had completely disappeared." The stickiness is not a true cement, it is merely an albuminous substance, not a fluid 'chitin' capable of forming an outer envelope.

While it is not easy to say exactly how the stalked attachment between the eggs is produced, it is still possible to describe a process by which the same might be arrived at.

I have not seen the newly-extruded egg, but assume that on passing out of the oviduct it will show little if any perivitelline space. The egg in gaining contact with sea-water would immediately begin to develop a perivitelline space. The extruded eggs lying on the abdomen would, by the mutual pressure due to their weight, tend to cause the expulsion of some of the perivitelline fluid by the micropyle (which, although it has not yet been described, very probably exists). Through this the now flaccid chorion might be glued to an egg, which in a similar way might attach itself to a third or to the first egg. Again, these eggs may have been pierced by the hairs without actually becoming attached to them. The eggs that are attached to one another are close to the base of the pleopod, where they are not subjected to any very violent movement. They are often found on the outside of the eggs which are attached to a fascicle of hairs.

The weight of the egg tends to stretch out the ductile chorion into long thin stalks. Two attachments may sometimes be seen to one broad stalk.

Nephrops norvegicus.—The pleopod is short and paddle-like; the endopodite is 2-jointed. Both branches are fringed with densely plumose setæ. The egg-hairs (fig. 64) have sharp points, and are ciliated near their extremities; the cilia are small, soft, and blunt. Sometimes the fourth of the length of the hair is ciliated. The egg-hairs are arranged round the periphery of the hind surface of the endopodite; they are also found on the protopodite. At the joint on the endopodite the projecting corner of the proximal segment bears a fascicle of egg-hairs. The egg-hairs do not carry nearly so many eggs as they do in the *Brachyura*.

Crangon vulgaris.—The egg-hairs are short, but more than one egg is strung on one hair. The eggs are attached to the protopodite, not to the endopodite or exopodite.

Pandalus Montagu.—In this form also the eggs are attached to the inner surface of the protopodite, and not to either the endopodite or exopodite. The egg-hairs are short.

The eggs are also attached to one another as in the lobster.

The duty of bearing the eggs is not allowed to interfere with the swimming function of the pleopod. In *Crangon* and *Pandalus*, where the pleopods are important swimming organs, the eggs are attached to the protopodite.

In *Homarus*, where the swimming function of the pleopod is practically in abeyance, the eggs are attached to the endopodite and exopodite, but not to their distal parts.

In the *Brachyura*, in place of a pleopod which performs both functions, viz. of swimming and of carrying the eggs, we have an organ which is suited solely for bearing and protecting the eggs. The endopodite is provided with special hairs to which the eggs become attached, while the exopodites function in protecting the attached eggs during the period of incubation.

Carcinus mænas.

The writer had the opportunity of observing part of the spawning process in *Carcinus*. Four females extruded their eggs at the Laboratory.

The ovaries of these and of a number of other crabs were examined. So far as could be made out, little difference exists between the process of spawning in this form and in *Cancer*.

The Formation of the Perivitelline Space in the Egg.

OVARIAN EGGS.—A number of non-berried impregnated female crabs (*C. mænas*) were examined in October, at a time when other individuals of this species were spawning. They measured in greatest breadth $1\frac{7}{8}$ in. and upwards. Of these, some had orange ovaries containing eggs which were practically ripe: others had pale, white, immature ovaries. The two classes differed in external appearance. The shells of the crabs which had orange ovaries were darker coloured than in the others. In the former the thorax and third maxillipedes especially showed some brown colour. In the crabs having immature ovaries the legs and thorax were of a light green colour, which indicated that they had cast more recently than the former (probably during the summer just past).

The ripe egg, on being extruded, soon shows a perivitelline space. In several instances when ovarian eggs, which were apparently ripe, were put into sea-water a small separation of the chorion from the vitelline membrane began to show itself, but although the eggs were kept in the water till next day no large or, in many cases, even distinct perivitelline spaces developed, except in those eggs in which the inner (vitelline) envelope had been ruptured, when large perivitelline spaces were rapidly (in half-an-hour) formed.

The formation of the perivitelline space would then appear to be due to the osmosis set up through the chorion by the presence between the chorion and the vitelline membrane of a fluid derived from the yolk. The non-formation of the perivitelline space in the above-mentioned eggs was possibly due to the fact that the complete ripening of the egg, viz. with the occurrence of this fluid between the two envelopes, had not yet succeeded.

A few ripe eggs were found in the spent ovaries of certain berried crabs. The spent ovary is a colourless empty sac, and shows here and there usually one or two ripe orange-coloured eggs which have not been extruded. In two cases examined none of the ovarian eggs showed a perivitelline space, but on being transferred to sea-water the spaces began to develop, and in a short time were large. In some cases the space was distinctly reddish-coloured. It would therefore appear that a change which makes the egg more favourable for osmosis takes place in the ripening, probably just before extrusion.

SPAWNED EGGS.—Some eggs which were taken by means of a brush off the thorax of a spawning female were found to have a very slight perivitelline space, but after they had been left in sea-water for a little they showed large spaces.

One female which was found spawning, or which had just finished that process, had surrounding it a thick layer of eggs on the bottom of the box. A small quantity of eggs only was attached to the endopodites. The crab was transferred to a glass vessel, and in the course of that operation a considerable quantity of eggs rolled off the abdomen. These eggs showed large perivitelline spaces, and most had a peak-like eminence on the exterior of the chorion.

The eggs lying free on the bottom of the box round the crab also showed large perivitelline spaces, but the little prominences were not seen on the chorion.

As was concluded in the case of *Cancer*, the perivitelline fluid is of a sticky nature.

Eggs picked off the bottom alongside the spawning female had large perivitelline spaces, with perfectly smooth chorion; there was no trace of any sticky fluid outside the egg.

The eggs which were displaced from the abdomen in transferring the spawning female to a glass jar from the box in which it had previously been kept lay on the bottom of the dish, and were with few exceptions emptied out of the dish by gentle rinsing. The few which remained attached to the glass were dislodged by the touch of a brush or with a pipette.

When the pipette was crowded with eggs, and in one case where the eggs were allowed to accumulate in a compact mass, on forcing them out some remained sticking to the glass. These were the eggs which showed the little prominences on the chorion mentioned above. On examining the end of the pipette with the microscope, at nearly every egg a little refractive globule was seen attached to the exterior of the chorion. This is without doubt the perivitelline fluid which has been squeezed out and which served to glue the egg to the glass in this case.

In another case the eggs which lay on the bottom of the box were found the next day to be stuck together in masses, which, however, readily broke. The attachment of the eggs to one another was probably due to the perivitelline fluid which the mutual pressure of the eggs would no doubt tend to press out. A similar condition was observed in the case of the unattached eggs of *Cancer pagurus*. After several days the eggs which lay on the bottom of the box had become attached together in masses.

The Spawning of C. mænas.

A crab which had just extruded its eggs on September 28th was surrounded by a quantity of eggs which looked like red dust on the sand. It was removed to a glass vessel and examined in water. It was then seen that the abdomen of the crab was being held away from the thorax and that it formed a kind of basin. The points of the endopodites lay on the openings of the vulvæ. A small quantity of eggs were attached to each endopodite, and eggs were noticed in the openings of each vagina. The endopodites were moved forwards, backwards, and outwards, widely separated laterally, inwards, and forwards. The independent movement of the distal part of the endopodite was seen. The exopodites move a little in unison with the endopodites in certain of the movements.

The crab gradually threw off the eggs that were attached to the endopodites.

On the endopodites a similar condition to that seen in *Cancer pagurus* was found. The chorion of the egg had been pierced by the hair and it was in a collapsed condition.

On October 16th a crab was examined which had spawned since the previous day. The eggs on the endopodite showed their outer envelopes (chorion) all wrinkled, but the yolk-sphere was not pushed to the pole away from the hair: it lay simply in the middle of the irregularly crinkled envelope. The stalk was not yet formed.

A considerable number of dead eggs was found attached to the endopodites of a berried *Carcinus* (October 14th) which had just spawned in the Laboratory. The inner or vitelline membrane had been ruptured and the yolk-sphere was broken up. It is possible that the yolk-sphere may have been pierced by the endopodite hair, though other agencies may have been the cause of their destruction.

Spawning seems to be completed within 24 hours.

Notes on Casting, Distribution, etc., of Cancer pagurus.

THE PERIODICITY OF SPAWNING AND CASTING.—Certain berried crabs were obtained during the summer of 1902. Their eggs hatched during August, September, and October. None of these crabs spawned again until the end of October 1903, when two did so. None of the crabs cast during the period.

In February 1904 two of the crabs were berried, and two were found dead. In the two latter the ovary was spent in one, and in the other was ripe but dropsical.

THE COLOUR OF THE SOFT CRAB.—When a crab has just cast it is a plump inert mass, which yields in all its parts to the slightest pressure of the fingers. It is of a dark purple colour all over the dorsum and dorsal surfaces of the pereopods: the ventral surface is yellowish white. As the shell hardens the dorsum gradually becomes of a lighter hue, turning into a brick-red colour. Meantime the third or white layer of the shell is thickening.

In the paragraph dealing with the migration of crabs the question of the abstention from casting is discussed in connection with one of the labelled crabs.

CASTING.—During the autumn of 1902, 31st August to 15th October, a number of female crabs cast in the tanks at the Bay of Nigg. With the exception of the first, all the females recorded in the following Table cast at this time. The size of the crab before and immediately after casting is shown in parallel columns opposite the date when the cast took place.

[TABLE.]

TABLE I.
CRABS THAT CAST IN THE MARINE LABORATORY, BAY OF NIGG.

Date.	Hard Crab —Inches.	Soft Crab —Inches.	Increase— Inch.	Ratio of Increase.
August 16, . . .	1½ ♀	1½	¼	1/5·5
„ „ . . .	1⅞ ♂	1½	⅜	1/4·6
„ „ . . .	2½ ♂	3½	¼	1/3·5
„ 31, . . .	4⅞ ♀			
September 1, . .	4½ ♀			
„ 6, . . .	4½ ♀	5 *	⅞	1/4·7
„ 8, . . .	4⅞ ♀	5½	⅞	1/5·5
„ 9, . . .	5½ ♀	6½	⅞	1/6·2
„ 10, . . .	5½ ♀	6⅞	1⅞	1/5·4
„ „ . . .	4⅞ ♀	5½	⅞	1/7·8
„ 11, . . .	3½ ♀	4½*	⅞	1/4·8
„ 16, . . .	1½	1½	¼	1/5·5
„ „ . . .	3½ ♀	3½	⅞	½
October 5, . . .	1 ♂	1½	¼	¼
„ 8, . . .	1½ ♂	2½	⅞	1/3·8
„ 9, . . .	3½ ♀			
„ 13, . . .	2½ ♀			
„ „ . . .	4½ ♀			
„ 16, . . .	4⅞ ♀	5½*	⅞	1/7·8

* Measured several days after casting.

As was previously* shown, the ratio of increase at each cast varies greatly. In the Table then given the ratio varied from $\frac{1}{3}$ to $\frac{1}{6}$. In the present case, in only one instance was the ratio greater than $\frac{1}{4}$, and it was as small as $\frac{1}{8}$.

The histological changes that accompany the ecdysis of the crab have been dealt with by Witten.

At the time when the crab casts, the shell of the three proximal joints of the chela becomes absorbed along certain lines, thereby allowing of the expansion of these joints to permit the withdrawal of the large claw. In fig. 100, Plate IV., is shown the cast chela. The absorption-lines are on the coxopodite, basi-ischiopodite, and meropodite, viz., *a/b*s. The part of the shell lying between the lines is movable. Similar absorption areas appear in the lobster (Herrick).

* DISTRIBUTION.—In discussing the question of the distribution of the crab, I was of the opinion that a group of crabs measuring from 2½ to 4 inches would be found to inhabit the shore waters just outside low-water mark. This group was distinct from the beach group, which is considerably smaller, viz. from $\frac{7}{8}$ to 2½ inches, and is itself smaller than the adult group, which measures from about 4 inches upward; it is required to fill up the very considerable gap which separates these two groups. (*Vile Pl. III.*) *

* “Contributions to the Life History of *Cancer pagurus*.”

TABLE II.—CRABS CAUGHT IN CREELS SHOT CLOSE TO THE SHORE. BAY OF NIGG.

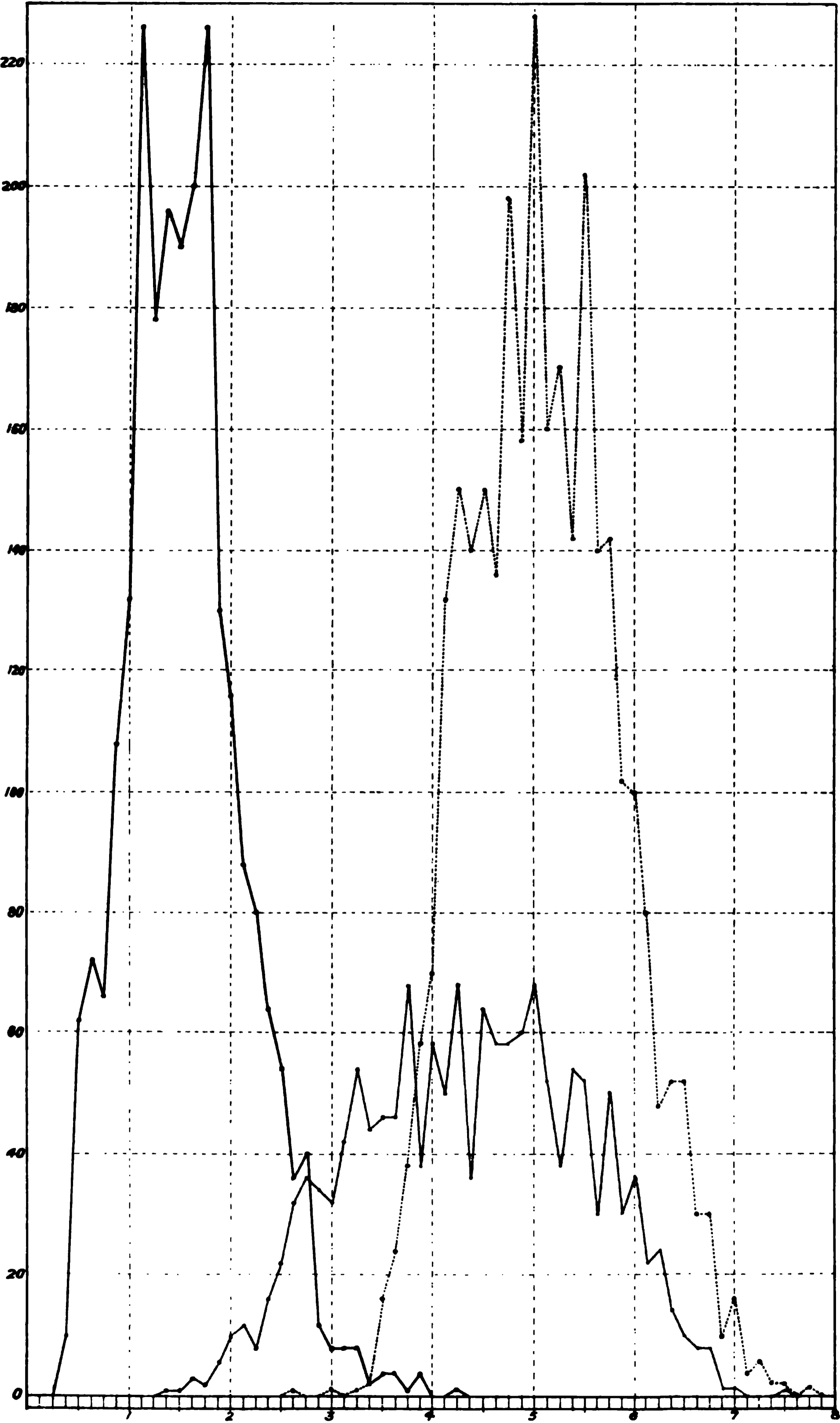
Date.	No. of creels.	No. of crabs.	No. of males.	No. of females.	No. of juv.	No. of unsexed.	Total.
1891.							
Jan. 10	1	1					1
Feb. 10	1	1					1
Mar. 10	1	1					1
Apr. 10	1	1					1
May 10	1	1					1
June 10	1	1					1
July 10	1	1					1
Aug. 10	1	1					1
Sept. 10	1	1					1
Oct. 10	1	1					1
Nov. 10	1	1					1
Dec. 10	1	1					1
1892.							
Jan. 10	1	1					1
Feb. 10	1	1					1
Mar. 10	1	1					1
Apr. 10	1	1					1
May 10	1	1					1
June 10	1	1					1
July 10	1	1					1
Aug. 10	1	1					1
Sept. 10	1	1					1
Oct. 10	1	1					1
Nov. 10	1	1					1
Dec. 10	1	1					1

* Sex not tested.

TABLE 11.—CRABS CAUGHT IN CREEKS SHOT CLOSE TO THE SHORE. BAY OF NIGG—continued.

* Sex not noted

Total—1523 Crabs.



2336 BEACH CRABS (♂ + ♀) II. 3029 CREEL CRABS (♂ + ♀) Ordinary Crab-Fishing, IV.
1523 CREEL CRABS (♂ + ♀) Creels shot close to the Beach - Group III.

With a view to testing the theory respecting this group (III.) a number of creels were shot during March to August in 1900 and 1901. They were set just outside low-water mark and were occasionally left dry by the ebb. Some of the creels were at times shot in 2 or 3 fathoms. One or two of the creels were covered with small-meshed netting. The number and sizes of the crabs got in each month are set out in Table II.

In March and April very few crabs were got. This was in part due to the fact that at that period of the year it often happens that bad weather prevents fishing for a considerable time, but this does not account for the small catches. Because even when the creels were fishing, it very often happened that no crab was caught. Their absence from the creels does not necessarily mean their absence from the region. They may not then feed eagerly. Crabs that are kept in the Laboratory during winter became very inactive. The cold has a much more paralysing effect on the edible crab than it has on *Carcinus maenas*, so that it is possible that the inshore crabs may not move about much before the month of May. In this month (May) a considerable number of crabs were got in the creels shot in the same place as in the preceding months. (*Vide* Table II.)

An examination of the catch of crabs shows that it consists of a large number of crabs which fall into the gap between the Beach and the Adult groups, but it also contains a large proportion of adult crabs. The adult crabs appeared in the catches all through the summer.

The curve formed by the measurements of these crabs has been introduced into a chart along with the curves of the Beach and Adult crabs. The latter are taken from my previous paper (*Tables VIIIA and IX.*)

A reference to the chart shows that the new group (red curve) tends to fill up the gap between the two former groups. The curve overlaps both groups. It measures from about 2 inches to over 7 inches. The examination of the shore waters was not carried on during the whole of the year, and the inshore migration of the adult crabs introduces larger crabs than actually belong to the group under consideration.

We then have in the summer in the shallow inshore water a double group, consisting of the III. and IV. groups. In the autumn and winter, investigation will very probably show that the adult group will be entirely, or almost entirely, absent, and in these seasons, therefore, a better defined Group III. should be found.

RATE OF GROWTH.—As material for the study of the rate of growth of the crab, I have introduced here the measurements of the monthly collections made on the beach at Dunbar (Table III.), and also the details of the individual catches which were measured (Table V.). The totals were given in my former paper, and the regions where the catches were made are in certain instances given in *Table V.* I have also introduced three additional collections made on the beach, Dunbar, in 1899 and 1900 (Table IV.).

Mr H. T. Waddington, Bournemouth, has kindly furnished me with particulars of two series of casts of this form. The various ecdyses which the two specimens underwent have been carefully recorded by him, and he has permitted me to publish them here (Table VI.). The measurements of the successive casts of a third crab, which were presented by Mr. Waddington to Professor Howes, were kindly supplied to me by Mr. William Wallace, B.Sc., Lowestoft.

Specimen A. when captured, viz., in August, measured 3.25 mm.; it had probably been in the megalops stage not more than a month previously. When one year old it measured 30.75 mm., i.e., $1\frac{1}{4}$ inches; when two years old it measured nearly 46 mm., i.e., a little less than 2 inches across. Assuming that the rate of growth in nature approximated to the data here given, we should conclude that the beach group consisted of crabs in their second year, and that a crab of $4\frac{1}{4}$ inches across would be not less than three years, nor probably more than four years old.

TABLE III.—CRABBS COLLECTED TWICE MONTHLY BETWEEN TIDE-MARKS ON THE BEACH AT DUNBAR.
The Numbers Indicate Hard + Soft Crabs. The Numbers within brackets indicate Soft Crabs alone.

* In 5 of these, viz., ♀, 1.3, 1.5, 2.0, 3.0 cm. respectively, the sex was not noted.

TABLE III—continued.

50

TABLE III.—continued.

2	2
3	3

TABLE III.

18

TABLE III.

18

4

TABLE IV.—CRABS CAPTURED ON BEACH AT DUNBAR.

SIZE.		May 1899.		June 1900.		August 1899.		SIZE.		May 1899.		June 1900.		August 1899.		May 1899.		June 1900.		August 1899.	
Cm.	Inches.	♂	♀	♂	♀	♂	♀	Cm.	Inches.	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
1.1		-	-	-	-	-	-	2.5	1	-	-	3	3	3	4	3	3	-	-	-	-
.2		-	1	-	-	-	-	.6		-	2	-	-	-	-	1	2	-	-	-	-
.3	½	1	-	1	-	-	-	.7		3	1	-	-	-	-	3	3	4	3	4	2
.4		3	2	-	-	-	-	.8	½	3	3	6	2	1	-	-	1	-	-	-	-
.5		7	3	-	-	-	-	.9		2	-	-	-	-	-	1	3	-	-	-	-
.6	½	2	2	-	1	2	-	3	½	3	3	-	-	-	-	-	1	3	6	1	4
.7		1	1	-	-	-	-	.1		2	2	-	-	-	-	1	1	-	-	-	-
.8		2	-	-	-	-	-	.2	½	3	3	5	6	-	2	-	1	-	-	-	-
.9	¾	2	1	-	1	1	2	.3		8	5	-	-	-	-	2	1	-	-	2	1
1		-	4	-	-	-	-	.4		5	-	-	-	-	-	-	2	-	1	-	-
.1		2	-	-	-	-	-	.5	¾	2	-	4	5	-	3	2	2	-	-	-	-
.2	¾	2	1	1	-	-	2	.6		5	5	-	-	-	-	3	-	-	-	-	-
.3		2	1	-	-	-	-	.7		4	3	-	-	-	-	1	2	4	4	-	2
.4		1	1	-	-	-	-	.8	½	3	1	3	1	3	3	1	1	-	-	-	-

TABLE IV.—CRABS CAPTURED ON REACH AT DUNBAR.—continued.

Size.		May 1899.		June 1900.		August 1899.		Size.		May 1899.		June 1900.		August 1899.	
Cm.	Inches.	♂	♀	♂	♀	♂	♀	Cm.	Inches.	♂	♀	♂	♀	♂	♀
5.3		4	2	-	-	-	-	6.6		-	3	-	-	-	-
5.4	2½	1	-	1	6	-	1	7	2½	-	1	2	1	-	-
5.5		2	2	-	-	-	-	8		1	2	-	-	-	-
5.6		2	4	-	-	-	-	9		1	-	-	-	-	-
5.7	½	3	3	2	4	1	1	7	½	1	1	1	4	1	3
5.8		2	-	-	-	-	-	1		-	1	-	-	-	-
5.9		2	1	-	-	-	-	2		1	-	-	-	-	-
6	¾	3	-	3	3	-	1	3	¾	-	-	1	1	-	1
6.1		2	5	-	-	-	-	4		1	1	-	-	-	-
6.2		1	-	-	-	-	-	5		1	-	-	-	-	-
6.3	½	2	1	3	3	1	1	6	3	1	-	3	3	1	-
6.4		1	-	-	-	-	-	7		-	-	-	-	-	1
6.5		2	3	-	-	-	-	8	4½	1	-	-	-	-	-

TOTAL, { May—♂, 122: ♀, 101
 June—♂, 52: ♀, 61
 August—♂, 21: ♀, 33 } 390 Crabs.

TABLE V.—CREEL CRABS, DUNBAR. December 1897 to August 1899.
TOTALS at each Size. The number of SOFT Crabs is shown within brackets alongside the Total (HARD and SOFT).

SIZE.		Dec. 20, 1897.		Jan. 28, 1898.		Feb. 25, 1898.		Mar. 31, 1898.		May 3, 1898.		May 27, 1898.		June 3, 1899.		July 12, 1899.		Aug. 4, 1899.		Nov. 5, 1898.	
Inches.	Cm.	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
2½	6·7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
3	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3½	7·3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	7·6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
4½	7·9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	8·2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
5½	8·6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	(1)
6	8·9	-	1	-	-	-	-	-	-	3	-	1	2	-	-	-	1	-	(4)	(3)	(3)
6½	9·2	(1)	2 (1)	2	1	-	-	1	-	3	4	1	2	-	-	1	-	(1)	(2)	(3)	(3)
7	9·5	2 (1)	(1)	2	1	-	-	2	2	2	2	5	2	-	(1)	-	-	5	(7)	(7)	(7)
7½	9·8	2 (1)	6 (3)	3	2	-	-	3	4	3	4	-	7	1	-	-	4 (1)	-	(8)	(10)	(10)
8	10·2	6 (2)	5 (3)	5	3	-	-	5	1	1	1	1	5	2	1	3	7 (2)	3 (1)	(9)	(10)	(10)
8½	10·5	5 (3)	6 (2)	7	7	-	-	17	8	4	4	4	4	4	5	5 (1)	7 (4)	6	19 (16)	16 (15)	16 (15)
9	10·8	12 (3)	14 (1)	6	8	8	4	14	10	3	7	3	7	4	8	6 (1)	3 (1)	2	17 (15)	10 (8)	10 (8)
9½	11·1	(1)	2 (1)	9	13	17	3	12	11	4	7	4	7	2	5	3 (1)	6	3	13 (2)	4 (2)	4 (2)

TABLE V.—CREEL CRABS, DUNBAR.—continued.

Size.		Dec. 20, 1897.		Jan. 28, 1898.		Feb. 25, 1898.		Mar. 31, 1898.		May 3, 1898.		May 27, 1898.		June 3, 1899.		July 12, 1899.		Aug. 4, 1899.		Nov. 5, 1898.	
Inches.	Om.	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
4½	11·4	6	10	8	5	6	8	13	12	21	9	2	8	9	11	5	1	3	2	18 (5)	12 (4)
5	11·7	1 (1)	9	3	6	6	5	10	12	11	3	4	3	10	3	2	4 (1)	2 (1)	1	17 (4)	15 (3)
5½	12·1	6 (2)	8	7	7	12	14	18	11	16	19	7	6	9	4	1	1	1	4 (1)	26 (4)	21 (5)
6	12·3	-	2	11	5	6	18	14	14	12	12	2	9	5	2	3	2	1	1	27 (5)	12
6½	12·7	7	14	10	6	16	20	26	25	12	13 (1)	3	5	13	3	5	3	1	5 (2)	27 (2)	15 (1)
7	13	3	6	3	9	7	11	18	17	12	8	6	9	3	4	2	5	1	1	20 (4)	16 (3)
7½	13·3	4 (1)	7	7	4	9	14	15 (1)	20	10	9	3 (1)	4 (1)	2	7	4	-	-	4 (1)	30 (1)	18 (2)
8	13·6	1	2	5	4	14	9	19	10	9	9	2	7	4	3	3	1	5	6	21 (1)	9
8½	14	5 (1)	11	4	17	6	17	21	21	4	10	8	7	11	7	5	-	-	5 (1)	26 (2)	17 (1)
9	14·3	6 (4)	5	1	8	6	12	15	14	4	9	6	3	4	8	3	1	2	4	17	13 (1)
9½	14·6	3 (1)	4	6	8	7	14	6	12	8	3	4	3	9	4	3	3	1	7	18 (5)	14
10	14·9	(3)	3	5	11	3	9	5	5	6	4	2	4	5	1	5	1	1	9	8 (4)	13
10½	15·2	3 (1)	8	1	5	5	12	13	7	6	-	2	4	2	-	4	5	-	6	10 (4)	7 (1)
11	15·5	3	1	-	4	4	8	9	3	1	3	3	1	5	2	2	6	-	5	15	6
11½	15·9	2	3	1	7	2	-	2	2	1	1	-	1	1	2	3 (1)	2	1	4	4	9
12	16·2	(2)	-	-	6	2	5	2	4	-	4	1	1	3	2	3	2	-	5	4 (1)	6 (1)

TABLE V.—CREEL CRABS, DUNBAR.—continued.

SIZE.		Dec. 20, 1897.		Jan. 28, 1898.		Feb. 25, 1898.		Mar. 31, 1898.		May 3, 1898.		May 27, 1898.		June 3, 1899.		July 12, 1899.		Aug. 4, 1899.		Nov. 5, 1898.	
Inches.	Cm.	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
6½	16.5	(1)	3 (2)	-	4	1	3	4	1	2	1	1	1	8	-	2	-	1	3	9 (3)	8
7	16.8	-	-	1	2	3 (1)	2	1	-	3	1	-	-	4	-	-	1	3	5 (2)	4	
7½	17.1	1	1	-	5	1	1	-	2	-	1	-	-	5	2	2	-	4	-	4	
7¾	17.5	-	1	-	2	(1)	1	1	-	-	-	-	-	2	-	-	1	-	-	1	-
8	17.8	(1)	1	-	-	-	-	-	1	-	2	1	-	3	-	-	1	3	-	3	3
8½	18.1	1	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	1	1
9	18.4	-	-	-	-	-	2	-	-	1	-	1	-	1	-	-	-	-	1	-	-
9½	18.7	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
10	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-
10½	19.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	19.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
		98	136	108	160	143	192	240	221	199	166	79	114	131	85	78	66	48	94	393	298
Total, .				Hard.		Soft.		Hard and Soft.		3029 Crabs.											
		Males.		1355		152		1507													
		Females.		1405		117		1522													

TABLE VI.
WADDINGTON'S SERIES OF *Cancer pagurus*.

No.	Date.	Size— Mm.	Rate of Increase.	Interval Days.	No.	Date.	Size— Mm.	Rate of Increase.	Interval Days.
A					B				
1	4 Aug., 1899,-	♀ 3.25					9.25		
2	15 " " -	4.75	$\frac{1}{4}$		1	30 April, 1900,-	11	1/3.4	
3	7 Sept., " -	5.75	1/4.7	23	2	25 Aug., " -	15.5	1/5.2	117
4	6 Oct., " -	8.5	$\frac{1}{2}$	■	3	30 Oct., " -	18.75	1/4.7	■
5	3 Nov., " -	10.75	1/3.7	28	4	9 Feb., 1901,-	20.75	1/6.5	102
6	12 Dec., " -	14.5	1/2.8	■	C				
7	27 Jan., 1900,-	19.5	1/2.9	.46			♀ 12		
8	3 April, " -	24.5	1/3.9	66	1	7 Sept., 1896,-	12		
■	4 June, " -	30.75	1/3.9	63	2	25 Nov., " -	16	$\frac{1}{4}$	
10	30 Sept., " -	36.5	$\frac{1}{4}$	118	■	20 Mar., 1897,-	19	1/5.3	116
11	19 Mar., 1901,-	45.75	1/3.9	170	4	26 May, " -	24	1/3.8	67
12	5 Nov., " -	56.5	$\frac{1}{4}$	231	5	21 Aug., " -	30	$\frac{1}{4}$	87
					6	4 Nov., " -	37	1/4.2	75
					7	31 Dec., " -	46	1/4.1	67

The Migrations of Crabs.

TABLE VII—ADDITIONS TO THE LISTS OF LABELLED CRABS RECAPTURED.

—The following contractions are used in the above Table, viz. :—"m," mDe; "yrs." years; "S," Soft; "H.," Hard.

A number of labelled crabs which were received after the publication of the previous paper are recorded in Table VII. One of these crabs (the last in the Table), which is a male measuring $6\frac{1}{8}$ inches across, is especially interesting. It was recaptured after an interval of three years very near the place where it was set free. When liberated it was a soft crab, and it had not cast its shell during its period of freedom. The abstention of the large crabs from casting has been exemplified by a number of instances, but the time of abstention has only been determined by secondary proofs. For example, a crab is captured with an oyster attached to its back. Since the age of the oyster may be more or less accurately judged from its size, a part of the period that has elapsed since the ecdysis has been determined. Thus Buckland recorded two crabs which had on their backs three-year-old oysters: they could not have cast for three years. Another, now in the Ipswich Museum, is said to have a four-year-old oyster on its back.

The present case gives a definite abstention for three years at the time of capture. At the beginning of 1903 it had not cast, and would not probably cast then till the summer. This would make the abstention from casting four years. There, of course, comes a stage when the crab ceases altogether from casting.

Meek gives* a list of the labelled crabs set free on the coast of Northumberland and which have been recaptured at various times during 1902 and 1903. One of these is of special interest. Set free in October it was captured in the following July at Portlethen (near Aberdeen), a point about 80 miles to the north of the place of liberation.

The Changes in the Carapace of Cancer pagurus.

Cunningham in his paper on the early post-larval stages of this Crustacean drew attention to the great difference between the early and the adult form of the carapace. In the adult the carapace is broadly oval in shape, and is crenate at the edge. In the very young crab the edge is toothed. In his opinion the general resemblance of the carapace, in this stage, to that of *Atelecyclus heterodon*, along with certain other points of similarity, indicated a closer affinity between the two species than had previously been recognised.

I have had the opportunity of examining one of the series of casts belonging to Mr. Waddington (A, Table VI.). They are, with the exception of the first, shown in natural size in figs. 71–81. The changes which take place in the shell are well seen. In fig. 103 an enlarged drawing of the second of the series is shown; it measures 4.75 mm. across the broadest part of the back. The carapace has five main lateral teeth, of which the first forms the hind edge of the orbit, while the fourth projects laterally farther than the others. The main teeth are all serrated; between each two a secondary tooth is found. The rostrum consists of three dentate lobes. The edge of the orbit is serrated; and on the surface of the carapace and on the limbs there are numerous small teeth.

In the next stage (fig. 102)—5.75 mm. in greatest breadth—a very considerable advance on the preceding is noticed. The secondary teeth have increased in proportional size, and with the main teeth are now more lobate or rounded. All of the lateral edge and the margin of the orbit is minutely dentate. On the rostrum the three lobes show merely a minutely notched anterior edge—the serrations being rounded, not tooth-like. The chela is furnished with tooth-like tubercles.

* Meek, "The Migrations of Crabs."—*Northumberland Sea-Fisheries Committee. Report on the Scientific Investigations for the year 1903.* Newcastle-on-Tyne, 1904.

Fig. 101 shows the stage immediately following, viz., 8.5 mm. The lateral teeth of the carapace are now lobes having minutely notched edges; the secondary lobes are almost as large as the primary. The margin of the orbit and rostrum is minutely notched. The tubercles on the chela are rounded.

In the succeeding stage, 10.75 mm. (fig. 98), a condition closely approaching the adult is to be noted. The notched edge of the lateral lobes of the orbit and rostrum is still more prominent than in the adult. The tuberculated chela is very noticeable. A distinction in size between the primary and secondary lobes is still to be seen. The edge of the carapace shows a triple row of tubercles. The dorsum also is tuberculated.

The sixth cast, 14.5 mm. (fig. 76), is represented in figs. 99 and 97, the former showing the frontal region. The lobes of the edge of the carapace are on the whole very similar to the adult condition. The chela is still tuberculated, and the triple row of tubercles which has succeeded the notches is very prominent.

In the cast shell shown in fig. 77 (19.5 mm. across) the tubercles are prominent but smaller.

They are further reduced in the next stage, viz., 24.5 mm. (fig. 78), and in that immediately following, viz., 30 mm. (fig. 79), the tubercles are practically reduced to the condition in the adult.

Fig. 81, the last of the series, was not made from the actual specimen, but is a drawing of a crab of the same size.

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<i>A.</i> —antenna.	<i>mu.</i> —muscle.
<i>a.</i> —basal bone.	<i>o.ch.</i> —outer chevron (1st abdom. seg.).
<i>ab.</i> —abdomen.	<i>o.l.</i> —outer layer.
<i>an.</i> —anus.	<i>1p.-2p.</i> —first and second penes.
<i>ant.</i> —antennule.	<i>p.-p.</i> —plane of movement of distal parts of endopodite of right side.
<i>ar.</i> —arm of second penis.	<i>p'.-p'.</i> —plane of movement of distal parts of endopodite of left side.
<i>b.</i> —basal bone.	<i>p.f.</i> —perivitelline fluid.
<i>c.</i> —core. —cæcum, fig. 38.	<i>r.</i> —rod.
<i>car.</i> —carapace.	<i>sl.</i> —solid in spermatheca.
<i>chr.</i> —chorion.	<i>s.e.</i> —secondary envelope.
<i>dis.</i> —egg with distended chorion.	<i>sp.</i> —sperms.
<i>e.</i> —eye.	<i>sp.w.</i> —wall of spermatheca.
<i>en.</i> —endopodite.	<i>th.</i> —thorax.
<i>ex.</i> —exopodite.	<i>v.</i> —valve, vulva.
<i>f.</i> —follicle.	<i>v.d.</i> — <i>vas deferens</i> .
<i>g.p.</i> —genital papilla.	<i>v.m.</i> —vitelline membrane.
<i>i.ch.</i> —inner chevron (1st abdom. seg.).	<i>v.w.</i> —wall of vagina.
<i>i.l.</i> —inner layer.	<i>yk.</i> —yolk.
<i>j.</i> —joint.	
<i>m.</i> —membrane.	

EXPLANATION OF PLATES.

PLATE II.

All the drawings are of *Cancer pagurus*, with the exception of Figs. 27, 28, and 29, which are of *Munida rugosa*.

Figures 1, 3, 5, 11, 12, 18, 21, 23b, 24, 34, 35, and 36 were outlined by aid of the *camera lucida*.

- Fig. 1. Eggs impaled by hair of endopodite. November 30, 1900, × 57
- Fig. 2. Lobule of ovary, showing a few distended eggs, *dis.* magnified, × 57
- Fig. 3. Eggs in later stage of attachment than Fig. 1.
- Fig. 4. Transverse section of first penis near base, magnified.

- Fig. 5. Section of a ripe egg (in ovary).
 Fig. 5a. Envelopes of egg, x 57
 Fig. 6. Hair of endopodite, magnified.
 Fig. 7. Part of long hair of exopodite, magnified.
 Fig. 8. Part of short hair of exopodite, magnified.
 Fig. 9. Ocular section of hair of exopodite, magnified.
 Fig. 10. Transverse section of first penis at the base, magnified.
 Fig. 11. Hair of exopodite, x 19
 Fig. 12. Hair of exopodite, x 19
 Fig. 13. Abdomen, showing relation of the swimmerets.
 Fig. 14. Side view of the abdomen, showing the overlapping of the
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 Fig. 15. Abdomen.
 Fig. 16. Transverse section of median part of first penis, magnified.
 Fig. 17. Ocular section of hair of exopodite, near its base.
 Fig. 18a. Longitudinal section of an egg which had been attached to a hair
 of the endopodite. January 11, 1901, x 57
 Fig. 18b. Section of envelopes of 18a.
 Fig. 19. Shows the eggs retained in the "incubatory chamber," formed
 by the abdomen.
 Fig. 20a. Third swimmeret, left side, posterior surface.
 Fig. 20b. Third swimmeret, left side, anterior surface.
 Fig. 21. Group of eggs attached to a hair. January 11, 1901, x 5
 Fig. 22. Tip of hair of endopodite, magnified.
 Fig. 23a & b. Tip of hair of endopodite, magnified.
 Fig. 24. Tip of hair of endopodite, oc. 2, obj. 2 mm. O.I.
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 Fig. 27. Tip of hair of endopodite of *Munida rugosa*, magnified.
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 Fig. 31. Tip of hair of endopodite, magnified.
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 Fig. 33. Tip of hair of endopodite, magnified.
 Fig. 34. Section of dropsical ovarian egg with large perivitelline space.
 Fig. 35. Hair of exopodite, x 19
 Fig. 36. Hair of exopodite, x 19

PLATE III.

The drawings, except where otherwise stated, belong to *Cancer pagurus*.
 Figures 56, 57, 58, and 64 were outlined by means of the *camera lucida*.

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PLATE IV.

Figs. 94, 95, and 96 were outlined by means of the *camera lucida*.

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 Fig. 105. Tip of second penis, do.

N.B.—The "arrows" which accompany certain of the figures serve to indicate the antero-posterior median line; the point of the arrow is directed anteriorly.

P.

0.00

0.01

0.02





III.—THE RATE OF GROWTH OF FISHES. By Dr. T. WEMYSS
FULTON, F.R.S.E., Superintendent of Scientific Investigations.
(Plates VI.-XII.)

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1. INTRODUCTION.

The present paper contains the results of further observations I have made on the rate of growth of fishes, and is a continuation of the investigation on this subject as dealt with in some of the preceding Reports of the Fishery Board. In that for 1901 I described fully the methods adopted,* the collections being obtained by the use of a fine-meshed net around the cod-end of the otter trawl, on the occasions when steam-trawlers were employed in the trawling investigations in the Moray Firth and Aberdeen Bay. It need only be mentioned here that the fishes are measured in millimetres, the measurements tabulated, and curves formed on the measurements as grouped into 1cm. or .5cm. groups. It may be stated that the method of collection with a small-meshed net in the way described has now been adopted in some other countries as well as on the "Goldseeker," the vessel employed in the Scottish part of the international investigations of the North Sea.

In addition to the measurements of numerous fishes, only part of which are worked up in this paper, viz. those dealing with the sprat, the witch, the Norway pout, and the sharp-tailed *Lumpenus*, observations were also made on a large scale with the view of determining the relation between the weight and the length of a considerable number of species, and these are detailed below. I have found that the law which governs the relation between the weight and dimensions of similarly-shaped bodies does not apply with precision to fishes. They increase in weight more than the increase in length would, according to the law, imply, and since the number of fishes in which the relation between the length and weight has been determined was large, viz. 5675, belonging to nineteen species, and in no case has the law been found to apply exactly, it appears to be well-established that on the assumption that the specific gravity of the fishes does not change during growth they must increase in some other of their dimensions, whether breadth or thickness, in greater proportion than they increase in length.

* *Twentieth Ann. Rep.*, Pt. III., p. 326.

I have likewise carried on a number of experiments in order to ascertain the relation which exists between the growth of fishes and the temperature of the water in which they live. It is well known from previous observations that in the winter season the growth of fishes, at least in the inshore waters, is slower than it is in summer; in the case of those living in shallow water, subjected to the changes in the temperature of the air, and where the extremes of heat and cold are at their maximum, growth may be entirely arrested in winter. In the Annual Report of the Board above referred to I gave particulars on this point with regard to the young plaice living on the beaches, and exhibited a curve in which the relation between the temperature of the water and the degree of growth of the plaice was established.

The experiments, which are described in detail below, consisted in keeping fishes of various species in tanks in which the water was artificially heated, and the result on the growth of the fish was very marked, those in the water of a high temperature growing much faster than those in the water at lower temperature. It was, moreover, shown, as might have been anticipated, that the fishes in the warmer water ate much more food than those in the colder water, the digestive ferments being more active at the higher temperatures, and the fish being thus able to digest a larger quantity of food in a given time. It was found that the appetite of the fishes was in relation to the power of digestion, that is to the temperature of the water, those in very cold water scarcely eating at all, although abundantly supplied with food. In the same way, the metabolism in the tissues was more rapid, and nutrition and growth much accelerated.

Certain differences were found to exist in different species, which are referred to below.

2. THE RELATION OF LENGTH TO WEIGHT.

In dealing with the rate of growth of fishes it is customary to take one of the dimensions of the fish and compare the variations of this dimension at different periods or in different collections. In some cases, as with the rays, it is more convenient to take the breadth across the pectorals than the length. The selection of one dimension for comparative measurement is very convenient, and it is accurate on the assumption that the fish grows equally in all directions, increasing in breadth and thickness in the same ratio as it does in length. It is obvious, however, that the true criterion of growth is the increase in the mass of the fish, and this can be determined either by the variation in the volume or in the weight.

The determination of the variation in volume is a somewhat slow process, and the methods are subject to difficulties in practice. With small fishes a burette may be used with accurate results; with those of large size the quantity of water displaced by the fish was measured separately in a burette, the fish itself being placed in a convenient vessel. In the case of fishes of moderate dimensions the method used was to place them in a vessel provided with a syphon to draw off the amount of water displaced, which was then measured in a burette; the bore of the syphon being so adapted as to always remain full of fluid. As a rule this mode of determining the increase in bulk was found to be less satisfactory than the method of weighing the fish, and this was the method chiefly employed.

According to the well-known law, that the volume of similarly-shaped bodies of the same specific gravity vary directly as the cube of corre-

sponding dimensions—a law which was brought prominently forward by Herbert Spencer in his “Principles of Biology”—a fish which has doubled its length should have increased its weight eight times. This law is a very convenient one in considering the rate of growth of fishes, all that is required, if the law holds true throughout, being to determine the relation between the weight and one of the dimensions at a particular size and then calculate the ratio between that dimension and the weight at different sizes. The truth of the law has not, however, been proved experimentally in the case of fishes, as far as I am aware, and it was decided to actually measure and weigh a large number of fishes of different sizes, and to construct curves in order to bring out the relation between the length and the weight at different sizes. In the Twentieth Annual Report of the Fishery Board* I described the method of presentation I had adopted, the abscissæ in the diagrams representing length and the ordinates weight; and I pointed out that the curves varied for different species, and that they did not everywhere agree with the rule as to similarly-shaped bodies above referred to.

Since then many more fishes and observations have been added to my lists, and I propose to discuss some of the results now.

In all cases, unless where otherwise stated, the observations have been made at different times of the year, and on fish from different localities. This method will give a better result as to the relations between length for the species generally, although it is probable that the ratio varies somewhat at different places and at certain times of the year—at all events in fish which have reached adult size. This is referred to at greater length below.

In the observations made on this subject each fish was individually measured in millimetres and then weighed in grammes, and the method adopted in presenting the results was to collect the records of weight to the nearest .5 centimetre, and take the mean of the lot. Thus the number of observations under each .5cm. are often unequal in amount; but it was found, on testing the method, that this system gave practically the same result as when the calculations were made for the observations under each millimetre measurement—a very laborious process.

The mean weight under a given .5cm. was then tabulated, as well as the number of fishes at that size and the greatest and lowest weight among them, and this information for the various fishes dealt with is given in a series of tables appended (p. 205), while the average weight is represented in the series of diagrams (Pls. VI, VII). In constructing these curves the average weight of the fishes at a particular length was not itself taken, the series of averages being arithmetically smoothed, by taking the mean of the averages immediately before and after; as a rule only the one preceding and the one following was combined with the average being smoothed, but in some cases where the number of observations was small a number of the preceding and succeeding averages were combined also and the mean taken.

The fishes in which the relation between the length and weight at different sizes were determined were the following:—Plaice, common dab, lemon dab, long rough dab, witch, brill, cod, haddock, whiting, herring, sprat, Norway pout, and partly also the turbot, little sole, gurnard, halibut, flounder, armed bullhead, and *Lumpenus*.

It will be seen from the tables and the curves of these fishes how very greatly the weight for a given length differs in different species, and thus how very different is the increment of growth for a given increase in the length. Among the food-fishes examined by far the heaviest in proportion

* Page 334, 1902.

to its length is the turbot, and after it comes the brill; at the opposite extreme is the witch, which is the lightest of all:—



Among the other flat-fishes the lemon sole comes after the brill, then the plaice, common dab, flounder, and long rough dab, but several of them are very close together. Among the round-fishes the cod is the heaviest in proportion to its length, with the haddock next, and then the whiting. The sprat is, in proportion to its length, heavier than the herring, which shows much the same ratio as the long rough dab. It is noteworthy that the extremes in regard to the length-weight ratio should be exhibited among the flat-fishes.

It will also be noticed that the variation in weight at a given size in the same species increases very much as the fish grows in length, so that at the larger sizes, of the cod or turbot for example, the variation in this respect is most pronounced. For this reason the terminal parts of the curves are less satisfactory than the lower parts, as may be seen in the diagrams, and it would probably require a very extensive series of observations on these larger forms to give the relation between the length and the weight with high precision. Nevertheless, I think the curves given will be found useful in dealing with many questions connected with the fisheries.

The number of the various species which have been measured and weighed for the purpose of this research are as follows:—

Cod, - - -	471	Little sole, - - -	54
Haddock, - - -	844	Turbot, - - -	29
Whiting, - - -	507	Brill, - - -	100
Norway pout, - - -	218	Flounder, - - -	48
Plaice, - - -	913	Halibut, - - -	38
Lemon dab, - - -	165	Herring, - - -	482
Common dab, - - -	541	Sprat, - - -	339
Long rough dab, - - -	335	Gurnard, - - -	63
Witch, - - -	426	Armed bullhead, - - -	59
		<i>Lumpenus</i> , - - -	43

—the total being 5675 fishes.

An examination of the tables and curves shows that the law in regard to the increase in weight according to the cube of the length, although broadly true, does not accurately apply in the case of the fishes examined. With scarcely an exception, the weight at a given length is greater than the weight calculated from the law, so that if the specific gravity of the fishes remains constant they must increase somewhat more in other dimensions than in length.

In the case of the haddock, the plaice, and the sprat, I have calculated out the weights at the various sizes on the assumption that the law referred to held true during the growth of the fish, and these are given in the Table on pages 240, 241. It will be seen, by comparing them with the weights actually observed, that the latter exceed the former in all cases as stated. The datum for the calculation in each instance was the smoothed average for the smallest sizes of which the relative numbers were large. The salient features in this comparison may be given here as follows, the weights being in grammes :—

Cm.	PLAICE.		HADDOCK.	
	Observed Weight.	Calculated Weight.	Observed Weight.	Calculated Weight.
1	—	·009	—	·008
3	—	·252	—	·213
5	1·17	1·167	—	·984
8	4·78	4·78	—	4·03
10	9·62	9·34	7·8	7·87
15	34	31·51	28·3	28·56
20	77·10	74·70	65·7	62·97
25	161	145·90	140·2	122·97
30	299·10	252·10	243·3	212·50
35	484·6	406·45	381	337·44
40	707·9	597·50	591·6	503·73
45	1,026	850·84	828·2	717·19
50	1,429	1,167·20	1,117	983·80
55	1,820	1,553·44	[1,440]	1,309·47
60	2,371	2,016·79	[1,915]	1,700
65	[3,331]	2,564·17	[3,214]	2,162·14
70	[3,908]	3,251·59	—	2,699·52

The figures in brackets represent individual fishes at or very near the dimension stated.

The comparison in the case of the sprat was as follows :—

Centimetres.	Observed Weight.	Calculated Weight.
1	—	·005
2	—	·043
3	—	·149
4	—	·343
5	·67	·670
6	1·17	1·190
7	2·02	1·838
8	3·05	2·744
9	4·63	4·015
10	6·71	5·36
11	9·48	7·13
12	12·46	9·52
12 5	14·34	—
13	[16·4]	11·78
14	—	14·71

A simple method of determining the relationship, without calculating out the ratio at all lengths, is to compare the weights at twice the size ; according to the law the weight should be eight times greater. This has been done in all the possible cases throughout the tables, and, with a few exceptions in individual instances where the numbers were usually small, it has been found that the weight at twice the size is greater, and sometimes very considerably greater, than the law implies.

Thus, among plaice of which a large number were weighed (913) there is no exception to the statement made, from 4·5cm. on to 35–70cm. In all cases the weight calculated in this manner is less than the weight actually observed, and the excess over what is required by the law is in some cases considerable. The following examples may be given :—

Cm.	Observed Weight (Smoothed). Grammes.	Cm.	WEIGHT IN GRAMMES.		Excess.
			Calculated.	Observed.	
5	1·17	10	9·36	9·62	·26
8	4·78	16	38·24	41	2·78
10	9·62	20	76·96	77·10	·14
12	17·35	24	138·8	140·6	1·8
15	34	30	272	299·1	27·1
18	57·79	36	462·2	527	64·8
20	77·1	40	616·8	707·9	91·1
22	112·8	44	902·4	954	51·6
25	161	50	1,288	1,404	116
27	207	54	1,656	1,802	146
30	299·1	60	2,392·8	2,468	75·2

Throughout the tables of measurements for haddocks also the weight thus calculated is always under the weight observed, except in a few cases among the largest fishes. Whether this is due to the fact that the number of the fishes at the larger sizes is too small to show the true relation, or the difference is a real difference with age, cannot at present be decided. I give the selected examples for haddocks in the accompanying Table, with all the cases where the calculated weight is greater than the observed weight :—

Cm.	Observed Weight (Smoothed). Grammes.	Cm.	WEIGHT IN GRAMMES.		Difference.
			Calculated.	Observed.	
10	7·93	20	60·4	65·7	+ 5·3
12	13·6	24	108·8	118·3	+ 9·5
15	28·3	30	226·4	243·3	+ 16·9
18	48·3	36	386·4	425·2	+ 38·8
20	65·7	40	535·6	591·6	+ 56·0
22	91·4	44	731·6	777·6	+ 46
25	140·2	50	1,121·6	1,171	+ 49·4
26·5	165·6	53	1,324·8	1,379	+ 54·4
28·5	205·5	57	1,645·0	1,635	– 10
31	271·7	62	2,173·6	2,110	– 63·6
37	465·9	74	3,727	3,691	– 36

Among common dabs the observed weights are always in excess also, with one exception, where the calculated weight for a fish of 12cm. is 14·80 and the weight observed was 14·7 grammes. The difference in the smaller forms here is not so great as in those of moderate size. At 6cm. the calculated weight was 1·36 grammes and the observed weight 1·85 ; at 10cm. the calculated weight was 7·76 and the actual weight 12·31 ; at 8cm. the calculated weight was 32·96 and the weight observed 34·3 grammes ; at 20cm. the calculated weight was 69·76 and the actual weight 74·7 ; at 24cm. the calculated weight was 117·6 and the weight observed 142·3 ; at 30cm. the calculated weight was 224·8 and the actual weight 296·4 ; at 36cm. the calculated weight was 403·2 and the weight observed 487 grammes.

It was the same with the lemon dab, no exception being found. The calculated weight at 15cm. was 26·8 and the real weight 32·3 ; at 31cm. the former was 288·8 and the observed weight was 354 grammes ; at 36cm. the respective weights were 436·8 and 595 grammes, and at 40cm. they were respectively 714·4 and 788 grammes. With the Norway pout, the herring, the sprat, the long rough dab, the cod, the witch, and the whiting the same method shows the same general result, an excess of weight over that to be deduced from the law. I append here some of the figures where this appears :—

TABLE.

Cm.	Cod.		Whiting.		Witch.		Long Rough Dab.		Herring.		Sprat.	
	I.	II.	I.	II.	I.	II.	I.	II.	I.	II.	I.	II.
8	—	—	—	—	1·52	1·46	2·64	2·68	—	—	—	—
9	—	—	—	—	—	—	4·0	3·9	—	—	4·0	4·6
10	—	—	—	—	—	—	—	—	—	—	5·36	6·71
11	—	—	—	—	—	—	7·76	7·85	—	—	7·04	9·48
12	—	—	12	12·4	—	—	10·4	10·5	—	—	9·36	12·46
13	—	—	—	—	7·6	9·9	12·2	13·3	—	—	—	—
14	—	—	—	—	9·1	11·7	15·4	16·5	—	—	—	—
15	—	—	27·2	23·8	10·5	14	18·5	21·6	—	—	—	—
16	—	—	—	—	11·7	16·9	21·4	27·2	23·8	29·1	—	—
17	40	45·4	34·4	35·2	12·8	20	28·4	32·4	29	34·1	—	—
18	46·2	54	40·8	41·3	—	—	31·2	40·4	34·2	40·3	—	—
20	63·4	71·1	56·8	54·2	—	—	45·6	58·5	47·2	55·1	—	—
24	120	123·1	99·2	102·4	—	—	84	122	84·8	106·1	—	—
25	138·4	146·5	112·8	118	67·2	86·1	—	—	96·8	119·8	—	—
28	196·8	210·7	154·4	178·1	—	—	—	—	141·6	174	—	—
30	245·6	271·8	190·4	210·6	112·6	170·4	—	—	187·2	219·5	—	—
35	394·4	420	305·6	332	—	—	—	—	—	—	—	—
40	568·8	614·3	433·6	513	283	458	—	—	—	—	—	—
45	828	907	—	—	—	—	—	—	—	—	—	—
48	985	1,013	819	984	589	791	—	—	—	—	—	—
50	1,172	1,139	—	—	—	—	—	—	—	—	—	—
55	1,588	1,608	—	—	—	—	—	—	—	—	—	—
60	2,174	2,057	—	—	—	—	—	—	—	—	—	—
70	3,360	3,380	—	—	—	—	—	—	—	—	—	—
75	3,948	4,000	—	—	—	—	—	—	—	—	—	—
94	7,888	9,144	—	—	—	—	—	—	—	—	—	—
100	9,112	10,194	—	—	—	—	—	—	—	—	—	—
108	11,728	12,239	—	—	—	—	—	—	—	—	—	—

Among the exceptions to the statement that the rule does not apply the most common are to be found among the small and young forms and in the whiting. In many cases the weight of the smallest individuals whose weight may be calculated by the method described is under the ratio prescribed by the law, or in conformity with it, and thus differs from what obtains among the larger individuals. It seems not improbable that the explanation of this circumstance is that, in their early stages, the fishes grow in length in a greater ratio than they grow in other dimensions. This is specially observable among the whittings, witches, and long rough dabs, although in the case of the two latter, at all events,

the tendency is markedly in the opposite direction later on. In many cases in the very largest fishes a few exceptions also occur, and this may be due to defective nutrition with age, or to the fact that the number of the fishes of large size examined was much less and not sufficient to bring out the true relationship. It is to be observed that the statement that the law does not accurately apply is supported by that part of the tables and curves where the observations are most numerous, and which, as a rule, includes those fishes which are in adolescence.

Among cod the greatest number of exceptions were found to occur. The observed weight continued to be greater than that required by the law from 17cm. to 48cm., and then from that point to 69cm., with one or two exceptions, it was less. The number of specimens of the larger sizes was, however, comparatively small, and in the case of the cod many of these large specimens were weighed in May, after they had spawned. In most of the other cases it may be said, although spawning and spent fish are included, the number of these is small; and the sudden loss of weight immediately after spawning is marked, although it appears to be rapidly regained.

I am not at present able to offer any satisfactory explanation of the departure from the law of growth generally accepted in the case of fishes; and perhaps it may be said that the application of this law in biology has not yet been experimentally tested on a sufficient scale among many species of animals. In the growth of some animals there is no doubt that the ratio between the dimensions does not continue constant, and that consequently alteration of shape occurs in the course of growth. In the case of fishes the relation between the length and the weight is in many, and probably most, instances modified in connection with reproduction to a considerable extent, and it may also be altered by the changes which take place in certain of the viscera, as, for example, in the liver, and by the general conditions of nutrition due to season and other circumstances. For obvious reasons, variations in the quantity of food which may be in the stomach or intestine may be neglected. It has to be noted, however, as already stated, that the fishes at periods before reproductive disturbances begin show a marked departure from the law, and that changes arising from difference of season affect fishes at different sizes.

These tables and curves will also be of value in determining the average weight of specimens of different species belonging to different series or generations, and thus showing the increase of mass from one generation to another as well as the mean weight when the reproductive period is reached and the range of variation. An example may be here given from the plaice to show the amount of growth which may take place from one generation to another, and in the following Table I give the particulars as based on the measurements of over 1800 specimens in a haul in Aberdeen Bay in November:—

Series.	LENGTH (MM.).		WEIGHT (GRAMMES).		Mean Increase.
	Range.	Average.	Range of Mean.	Average.	
I.	[35—85	65]		2·5	
II.	91—162	118·1	6·9—42	17	14·5
III.	164—260	216·5	44—181	106	89
IV.	261—369	315	183—676	343	237
V.	363—442	400	620—970	708	365
VI.	444—479	460	990—1,280	1,092	384

From this it will be seen how very greatly the weight and therefore the amount of growth in different members of the same series may vary. The "range of the mean," moreover, refers to the average weight for the longest and shortest fish in a series; the actual or possible variation in weight is much greater, as may be seen from the Tables for the plaice on p. 205.

3. THE AVERAGE SIZE AT MATURITY.

With regard to the size and age at which the males and females of the various species of food-fishes first attain maturity, a great deal of information is still required. Isolated observations have been made in a considerable number of instances on several species, sufficient to give an approximate idea of the limit between the mature and the immature, but, as a rule, they are not of such a kind as to enable the average-size as well as the extremes to be determined, and on the hypothesis that reproduction takes place at a certain age this average-size should correspond to the average for one or other of the yearly groups.

In one or two cases I have made a number of observations on the subject, particularly with regard to the plaice, the haddock, and the whiting, a number of these fishes being examined at the spawning time, the sexes determined, the condition of the reproductive organs noted, and the size of the fish measured.

A number were also examined at periods anterior to the spawning time and the progress of the development of the eggs observed.

Thus, among twenty-four whittings caught in the Moray Firth on the 14th November, comprising sixteen females and eight males, it was found that the former ranged in size from 242 to 418mm., and in weight from 108 to 517 grammes; the weight of the ovary varying from 0·2 to 38 grammes, and the diameter of the eggs from ·189 to ·294mm. The following are selected examples:—

Length.	Weight.	Weight of Ovaries.	Diameter of Largest Eggs.
Mm.	Gr.	Gr.	Mm.
242	108	0·4	·189
248	110	1·0	·231
293	196	1·7	·294
298	198	1·5	·252
304	223	2·1	·231
313	240	1·8	·189
351	354	2·8	·273
418	517	38·0	·273

The particulars in these examples show that the whittings, and probably even the smallest, would spawn at the next spawning season; and it will be observed that the size of the eggs in some of the smaller specimens is as large as in those of considerably greater size. In the males the weight of the testes was also determined, and their weight did not always correspond with the weight of the fish, as the following examples indicate:—

Length.	Weight.	Weight of Testes.
Mm.	Gr.	Gr.
293	205	0·8
322	281	1·1
335	277	0·9
323	331	2·0
339	330	3·5
364	382	0·8

All these males would also in all probability spawn at the next season. On the 27th December some others, also taken in the Moray Firth, were examined, and the following shows the particulars in regard to some of the females:—

Length.	Weight.	Weight of Ovaries.	Diameter of Eggs.
Mm.	Gr.	Gr.	Mm.
175	40	·11	·063
227	81	0·7	·231
254	107·5	1·1	·189
260	113	3·5	·462
231	85	0·8	·210

In the males the testes were as small relatively as in those examined in November. Several other whittings of smaller size were examined, from 159 to 178mm., and in all cases the ovaries and testes were extremely small, and the eggs minute, the largest being about ·06mm.

On 23rd January another lot were examined, and it was found that both the weight of the ovary and the diameter of the largest egg had considerably increased, as shown by the following particulars of some of the females:—

Length.	Weight.	Weight of Ovaries.	Diameter of Eggs.
Mm.	Gr.	Gr.	Mm.
266	136	4·1	·609
269	160	1·8	·357
297	209	5·8	·609
302	224	3·9	·441
339	306	7·9	·462
341	335	11·7	·63

All these females would obviously spawn in the ensuing season ; and it is noteworthy that some of the smaller fishes had the larger eggs. The weight of the testes in the male had also increased ; in specimens from 227–232mm. they weighed 0·7–0·9 grammes, and in some from 253–267mm. they weighed from 1·2 to 3·8 grammes. From these indications probably all would spawn in the course of the next season.

On the 1st April, that is after the spawning season had begun, some others were examined. Females of 182 and 198mm. had small ovaries and unyolked eggs which measured from 0·6 to 0·8mm. Others at 225 and 227mm. ($8\frac{7}{8}$ inches) had eggs measuring up to ·672, and at 232 and 237mm. the ovaries contained ripe eggs. From the same collections 803 whittings were assorted into males and females, the condition of the reproductive organs being determined ; the particulars are contained in the following Table :—

FEMALE.				MALE.		
Cm.	Ripe.	Spent.	Immature.	Ripe.	Spent.	Immature.
13	..	..	1	..	..	..
14	..	..	3	..	..	1
15	..	..	..	..	..	..
16	..	..	4	..	..	6
17	..	..	4	..	..	4
18	..	..	1	1	..	3
19	..	..	1	2	..	1
20	1	..	1	16	..	2
21	4	..	4	33	..	4
22	18	..	..	58	..	2
23	33	..	3	77	..	1
24	40	..	3	70	..	..
25	44	..	3	65	..	..
26	40	..	1	56	..	..
27	38	1	..	28	..	..
28	27	..	..	21	..	..
29	13	..	..	9	..	..
30	13	..	..	8	..	..
31	10	..	..	3	..	..
32	7	..	..	1	..	..
33	4	..	..	1	..	..
34	1	..	..	..	..	..
35	3	..	..	..	..	..
36	..	..	..	..	..	..
37	3	..	..	..	..	..
38	..	..	..	..	..	..
39	1	..	..	..	..	..
40	..	..	..	..	..	..

In addition to these observations made on board the trawlers employed in the Moray Firth, in which the collections included many whittings too small to be marketable, the opportunity was taken to examine the sexual condition of a number of whittings as brought to market. These do not include the very smallest which may be mature, but they serve for

comparison, and they show, moreover, the very small proportion of this fish which is brought to market in the immature condition.

FEMALES.				MALES.		
Cm.	Ripe.	Spent.	Immature.	Ripe.	Spent.	Immature.
23	..	..	..	..	..	..
24	1	..	1	1	..	..
25	1	..	1	6	..	..
26	3	..	1	3	..	..
27	28	..	..	14	..	..
28	45	..	..	16	..	..
29	43	..	..	19	..	..
30	50	..	..	16	..	..
31	29	..	..	16	1	..
32	23	..	..	18	..	..
33	29	..	..	9	1	..
34	33	..	..	20	..	..
35	38	..	..	11	..	..
36	24	..	..	7	..	..
37	22	..	..	7	..	..
38	29	..	..	1	..	..
39	16	1	..	1	..	..
40	14	..	..	..	..	..
41	12	..	..	1	..	..
42	3	..	..	..	..	..
43	8	..	..	..	..	..
44	4	..	..	..	..	..
45	1	..	..	..	..	..
46	2	..	..	..	..	..

From these observations it appears that the female whiting may attain maturity when it is 20cm., or about 8 inches, in length, but that the average size when reproduction first begins is approximately 25cm., or about 10 inches.

This conclusion agrees with the previous observations made by me on the rate of growth of the whiting and the size and age at which maturity is reached. I stated in the Twentieth Annual Report* that the whiting when two years old had an average size of about 9 $\frac{7}{8}$ inches, the range being from about 7 $\frac{3}{4}$ inches to 12 inches, and that this was the generation which commenced to spawn. The tables given above show that some of the males may begin to spawn at a size less than that at which the females spawn, but the difference is not very great, and I am disposed to consider that the males also do not attain maturity till they are two years of age.

A series of corresponding observations were made in regard to the haddock, which serve to throw light on the size and age when maturity is first reached. On the 31st October a number were taken in Aberdeen Bay, the sexes determined, and the condition of the reproductive organs ascertained. The following shows the main features among the females —

* Part III., page 400.

Length.	Weight.	Weight of Ovaries.	Size of Eggs.
Mm.	Gr.	Gr.	Mm.
245	116·5	·3	·08
246	134	·5	·08-·1
253	141	·2	·08
276	182	·7	·2
341	412	2·5	·315
356	496	3·1	·315
387	616	2·7	·294
428	814	10·1	·37-·39
525	1,600	14·0	·36

On 12th November another series of observations were made on haddocks taken in the Moray Firth, and similar observations on collections obtained in Aberdeen Bay on 24th December and 14th January, and in the Moray Firth on 21st January. The particulars in some of the cases are appended :—

	Length.	Weight.	Weight. of Ovaries.	Diameter of Eggs.
	Mm.	Gr.	Gr.	Mm.
November 12	338	392	3·5	·42
	333	311	5·75	·357
	315	312	2·9	·399
	317	347	3·9	·378
	355	490	3·0	·315
	415	782	7·8	·378
	528	1,345	13·5	·378
December 24	307	265	4·2	·48
	329	366	6·1	·42
	341	365	5·3	·48
	390	637	43·8	·63
	416	737	14·7	·46
	518	1,387	30·3	·52
January 14	272	178	0·4	·12
	301	224	·26	·14
	313	254	1·2	·16
	325	318	1·4	·34
	326	340	6·5	·57
	348	367	7·0	·44
	381	467	2·2	·14
	383	583	21·5	·59
	432	738	17·6	·48
January 23	169	38	··	·04
	231	96·5	0·5	·273
	257	131·5	0·7	·12
	271	158	0·6	·31
	235	99·5	0·9	·36
	223	90·5	0·3	·18
	287	182	1·0	·315

Among those taken on 23rd January in the Moray Firth several at from 146 to 170mm. which were examined had the ovaries quite small and immature ; some of those of 257mm. and thereabout had only clear unyolked eggs measuring up to .1mm., while others of the same size, or even smaller, had eggs considerably larger, yolked, and would, no doubt, spawn before the close of the spawning season. This difference is, I think, to be explained by difference in age, the less matured individuals, although larger, being younger and belonging to a later generation.

On the 1st April, among a number taken in the Moray Firth, quite ripe females were got measuring 254mm. (10 inches) and 258mm. and weighing 134 and 141 grammes, or about 4½ ounces; others almost mature measured 256 and 258mm., while some quite immature were found measuring 283mm., or more than 11 inches. On the 23rd April a few females of 263mm. were ripe, and males of 255mm. and upwards and females of 258, 273, 296mm. and upwards were spent.

In the collection procured on 1st April a number of the ovaries were examined, with the following results :—

Cm.	Spawning or nearly Ripe.	Spent.	Immature.
16	..	..	1
17	..	..	4
18	..	..	..
19	..	..	1
20	..	..	3
21	..	..	10
22	..	..	24
23	..	..	30
24	8	..	27
25	15	..	14
26	11	..	4
27	5	..	2
28	5	1	1
29	2	..	3
30	6	2	..
31	4	..	..
32	8	1	..
33	7	1	..
34	12	..	..
35	6	..	..
36	3	..	..
37	1	..	..
38	5	..	..
39	2	..	..
40	1	..	..
41	..	..	..

The collection was a small one, and the larger fishes were for the most part absent. It shows, however, that females as small as 24cm. may be ripe and some as large as 29cm. immature, the average size at first maturity in this case being approximately 30cm., or about 12 inches, which is rather under the size brought out by some other observations. Out of a large number examined on a former occasion the smallest of the

females obtained was 12 inches, and the smallest nearly mature 10 inches ; and Holt from his observations at Grimsby placed the average limit between the mature and immature at 13 inches.

Some observations were also made with regard to the size at which maturity is reached in the plaice by the examination of the fish as landed and also on board as brought to deck. In the latter case the examination was only towards the close of the spawning season, when most of the fishes were spent, and the information obtained in this way is therefore of more limited scope.

On the 11th and 16th February 259 were examined, of which 134 were females and 125 males. Among the former 50 were spawning, or had the ovaries so far developed that spawning could be said to be imminent. The largest immature female measured 440mm., the next largest being 436mm. The smallest female found to be actually spawning was 373mm., or about $14\frac{3}{4}$ inches, the next smallest being 382mm ; the smallest nearly ripe measured 360, 360, 368, and 378mm. The difference, therefore, between the largest immature and the smallest nearly mature was 80mm., or $3\frac{1}{8}$ inches. The numbers are not very large, but so far as they go they show that the average size when maturity is first attained is about 43 or 44cm., that is, approximately, 17 inches, the limit also found by Holt to apply to the plaice from the northerly part of the North Sea, and confirmed by Kyle.*

With the males the largest immature specimens measured 370, 367, and 366mm., and the smallest spawning males measured 306, 318, and 330mm.; the smallest nearly ripe was 317mm. and the next 322mm. The difference in this case between the smallest mature and the largest immature amounts to 64mm., or $2\frac{1}{2}$ inches. Probably the examination of a larger number of specimens would enlarge the difference both for the males and females, but as they stand they agree very well with the overlapping in length of the respective series or generations.

* *Eighteenth Annual Report Fishery Board for Scotland*, Part III., p. 190.

[illegible]

Of those examined on the 30th of March towards the end of the spawning time, two females were still spawning, their sizes being 43 and 53cm.; the number spent was 36, the smallest that was certainly determined to have spawned being 45cm. The number immature was 51, the largest being 46.5cm., but it is possible it had spawned early in the season. Among the males, of which 65 were examined, 11 were still spawning, the smallest measuring 38cm., or nearly 15 inches. Six were taken to be spent, the smallest being 37cm. and the largest of those immature was 38cm. Among the spent females it was, as a rule, easy to determine their condition from the fact that a small quantity of ripe eggs was still contained within the ovaries, sometimes amounting to a few teaspoonfuls.

Some observations were also made upon the cod, and although they were not very extensive, so little has been exactly determined for this fish that they may be given here. At the end of March, when I was on board a trawler, we hit upon a shoal of spawning cod in the Moray Firth, some hundreds being caught in each haul of the net, and very few other round fish were taken at the same time. They were actively engaged in spawning, the ripe eggs and the spermatoc fluid flowing from them, and some were spent. I was struck by the fact that among these fish there were none of a small size, and the great majority were cod of the largest dimensions usually landed. Among the smallest measured were the following:—Females 33, 35, and 35½ inches; males 29½ (quite ripe), 33½, 30, 34½, 35 inches. Among the few codlings taken I found one of 70.5cm. (27½ inches) quite immature; one at 56.7cm. (22½ inches) had an extremely small ovary. At Aberdeen on 18th April I found one measuring 72.6mm. (28½ inches) immature, and on the 11th February of a number of large codling examined after they had been landed I found males measuring 595mm. and 640mm. quite immature; in the latter the testes weighed only 5.3 grammes. The largest female was 60.7cm., or about 24 inches, and it was immature, the largest eggs in the ovary measuring .18mm in diameter, and showing faint deposition of yolk at the periphery.

From these facts I concluded that the size of the cod when maturity is first attained was probably considerably higher than is generally supposed, but in the Moray Firth on the very next day, viz. 1st April, a cod was taken in 32 fathoms off Burghead with large and perfectly mature ovaries. It was 65cm. (25¾ inches) in length and weighed 7lbs. 2½oz., the roe weighing 432 grammes (15½oz.). This fish had just begun to spawn, and it was clearly of quite a different class from the great spawning shoal above alluded to, in which the smallest spawning female measured 84.0cm.

It may be added that on the 12th November codling taken in the Moray Firth, and measuring from 535 to 610mm., had small ovaries, weighing from 3.1 to 6.83 grammes, the diameter of the largest eggs being .147 and .2mm; while cod of 92.7 and 102.9cm. had the ovaries weighing 111.5 and 161.3 grammes respectively, the diameter of the largest eggs being .22mm. On the other hand, a cod of 74.7cm., taken in Aberdeen Bay on 31st October, with ovaries weighing 56.5 grammes, had eggs up to .50mm.

The average size fixed by Holt for the cod on first attaining maturity, viz. 25 inches, would therefore appear to be by no means too high; many cod, as he points out, undoubtedly reach a considerably larger size before spawning. The smallest ripe female obtained by him measured 26½ inches; it was thus somewhat larger than the small one above recorded from the Moray Firth. He, however, obtained one which was three

parts ripe and measured $22\frac{1}{2}$ inches. On the other hand, among those examined during the spawning season he found females immature as large as 36 inches.*

IV.—THE INFLUENCE OF TEMPERATURE ON THE GROWTH OF FISHES.

In one of my previous papers dealing with the growth of fishes I referred to the important influence which the temperature of the water exercises over the rate of growth, and gave examples from the observations made on certain species, and particularly the plaice in its younger stages when inhabiting the sandy beaches.† It was shown also that the haddock and whiting and other forms increase in length much more rapidly in summer than they do in winter, but from the want of a series of periodic observations on the temperature of the deeper offshore water in the various months throughout the year, it is not yet possible to bring the observations on growth into exact relation with the temperature variations in the water.

It appeared to me that some results of interest might be obtained directly by keeping fishes in the winter in water which was artificially heated, and comparing their growth with other fishes kept under similar conditions but in water at the ordinary temperatures. This has been done for over five months with the results described below.

Four different lots of fish were kept in separate and similar tanks, which may be distinguished as No. 1, No. 2, No. 3, No. 4. Each of the tanks is of concrete with the front and back of plate glass, and the light from windows in the tank-house passes through them, but not very strongly. The tanks are of uniform dimensions, measuring $5\frac{1}{2}$ feet in length by 4 feet 4 inches from back to front, and the depth of water during the experiments in Nos. 2, 3, and 4 was $25\frac{1}{2}$ inches; the volume of water in each of these tanks was therefore about 315·5 gallons, or 1433 litres. The other tank, No. 1, owing to a defect could not be filled so full, and in it the depth of water was 15 inches, the volume being thus about 185·5 gallons, or 842·5 litres. Tanks Nos. 1 and 2 were supplied from the ordinary supply pipe to the tank-house, the water thus having approximately the same temperature as the sea water on the beach. Tanks Nos. 3 and 4 were supplied with sea water from the same pipe, but it was first passed through a heating arrangement by which its temperature was raised. Considerable difficulty was at first experienced in raising the temperature of the water in these tanks sufficiently high. It was soon discovered that the use of oil heaters was insufficient, and the method adopted was to utilise an ordinary slow-combustion stove for heating the apartment, upon the top of which was placed a common galvanised iron hot-water tank, such as are used for supplying hot water, of forty gallons capacity, and around it was placed an iron jacket with a space between in which was enclosed the smoke pipe from the stove. This arrangement has answered very well and with comparatively little attention or extra cost.

No arrangement was employed for the mechanical regulation of the temperature, which varied considerably from time to time, as shown in the tables, falling generally during the night; but a little experience in firing enabled the variation to be to some extent controlled. The temperature was taken every few hours daily, and the supply of hot or cold water regulated accordingly, and maximum and minimum thermometers were also used in order to ascertain the extreme nightly range.

**Journ. Mar. Biol. Assoc.* III., Special Number p. 377, 380, *Ibid.* III., No. 1, 79.

†*Twentieth Ann. Rep.*, Pt. III., pp. 335, 342.

Inflow.			Tank No. I.			Tank No. II.		
Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
5.5	4.2	5.0	—	—	—	5.4	4.6	5.2
6.0	4.0	5.3	6.3	4.8	5.6	6.4	3.8	5.0
6.0	3.8	5.1	6.2	3.8	5.1	6.4	4.6	5.5
5.2	4.4	4.8	5.4	4.0	4.4	5.6	4.6	5.0
6.1	3.0	5.0	5.4	2.8	4.1	5.2	4.2	4.4
5.2	4.2	4.7	4.3	3.6	3.9	4.6	3.8	4.3
6.8	3.8	5.1	4.8	3.4	4.2	5.2	3.6	4.4
7.4	5.4	6.5	5.8	4.5	5.3	6.8	5.0	5.8
8.4	5.2	6.3	6.2	5.0	5.5	5.8	5.2	5.6
10.8	5.8	7.9	7.8	6.3	6.6	8.8	5.4	6.4
10.6	7.5	8.3	9.4	6.4	8.3	10.4	7.0	8.4
10.8	7.6	9.0	10.2	8.0	8.8	10.0	7.8	8.7
9.2	8.2	8.9	9.4	8.0	8.9	9.2	8.0	8.6
10.6	9.8	10.2	10.4	9.8	10.1	10.2	9.4	9.7
10.4	9.9	10.2	10.6	9.9	10.3	10.4	9.8	10.8

Tank No. III.					Tank No. IV.				
Max.	Min.	Average of			Max.	Min.	Average of		
		Max.	Min.	Mean.			Max.	Min.	Mean.
—	—	—	—	—	16.4	7.2	12.6	9.4	10.8
10.6	7.4	9.3	8.3	9.0	14.2	7.4	12.7	8.0	10.9
11.4	6.3	9.3	7.8	9.1	16.4	7.8	14.4	9.7	12.1
11.4	7.2	9.6	7.9	8.9	17.2	10.0	15.4	11.5	13.5
10.1	5.0	8.0	6.8	7.6	21.0	9.6	17.2	11.2	13.2
9.0	4.4	8.5	5.7	7.0	19.6	7.6	15.3	9.3	12.4
10.2	3.9	7.5	4.8	6.0	18.3	7.8	15.6	8.9	12.0
8.9	4.4	8.0	6.1	7.1	18.9	7.4	14.5	9.9	12.3
9.5	4.4	7.7	5.3	6.4	20.0	6.8	14.9	10.3	12.9
14.0	5.0	10.8	7.0	7.8	22.8	9.2	15.0	10.7	13.2
15.0	6.7	11.6	8.2	10.0	17.8	10.0	15.9	11.8	13.6
12.8	7.0	11.0	8.5	9.7	16.1	8.3	15.0	10.6	12.8
13.9	7.0	11.4	8.1	9.5	18.3	7.8	15.2	9.9	12.6
12.8	8.3	11.8	9.5	10.6	16.1	9.4	15.2	10.5	12.5
15.6	10.0	13.3	10.8	11.9	16.1	10.6	14.9	11.7	13.1

I have tabulated the temperature observations in the accompanying tables for each of the tanks, and for the supply as it came to the apartment. Tanks Nos. 1 and 2 were not supplied with hot water; Tank No. 3 got a partial supply, and Tank No. 4 the largest supply, and it is this tank which was looked to to give the best results.

The temperature observations are tabulated in ten-day periods for the 155 days over which the experiment extended, each showing the maximum and minimum temperature recorded, the mean for the ten days; and for Tanks 3 and 4 the mean of the maxima and minima have also been calculated.

It will be seen from the tables that the mean temperature in No. 1 varied from 3·9 C. to 10·3 C. during the 155 days, the mean for the whole period being 6·5 C. (43·7 F.); the extremes of temperature observed at any time were 2·8 and 10·6. The mean temperature of No. 2 varied from 4·3 C. to 10·8 C., the mean for the period being 7·0 C. (44·6 F.); the slightly higher temperature was owing to this tank being nearer the stove than No. 1. In No. 3 it was desired to maintain a temperature intermediate between that of No. 4 and the other tanks, but greater difficulty was found in this case in adjusting the supplies of hot and cold water. The ten-day means ranged from 6 C. to 11·9 C., the mean for the period being 8·6 C. (47·5 F.). The extreme individual temperatures were 3·9 and 15·6, a difference of 11·7 C., but these variations were of short duration. In No. 4 the range of the ten-day means was 10·8 to 13·6 C., the range of the mean maxima was from 17·2 to 12·6, and of the minima from 8·0 to 11·8; the extreme temperatures recorded were 6·8 C. (44·2 F.) and 23·8 C. (73·0 F.), a difference of 16 C. or 28·8 F. The low temperature as a rule occurred when the stove or some part of the apparatus required to be overhauled, and the high ones for a short period, when the fire had been too strong; they sometimes occurred during the night. The mean temperature for this tank for the whole period was 12·5 C. (54·5 F.), which approximates to the mean bottom temperature in the sea off the East Coast in July, August, and September; in depths of from ten to fifteen fathoms the mean temperature for these months is about 52·9, and a little further out, in thirty fathoms, it is 50·7 F.

The fishes used in the experiments were young whittings, codlings, and haddocks, a few dabs, a plaice, a small starry ray, and an armed bull-head. They were procured in the small-meshed net used around the otter-trawl in the investigations made on board trawlers, and were first kept for a few weeks after being brought to the laboratory before they were placed in the experimental tanks. Each fish was measured, but not weighed, nor was its volume determined; trial showed that the risks might be too great.

With regard to the general conditions and behaviour of the fishes a little may be said. They were fed daily, or several times a day, and in all cases they got as much food as they were willing or able to take, but they were not fed during the night. Their food consisted almost entirely of the ordinary edible mussel, chopped up, varied occasionally with a few limpets, and still more rarely with live shrimps; on one or two occasions they got fragments of herrings or parts of the roe or milt, and sometimes the mussels were not removed from their shells, but were broken up and crushed. An attempt was at first made to weigh the quantity of food given to them daily, but the conditions of the experiment showed that this might be misleading and it was discontinued.

All the fishes did not by any means thrive to a like extent. The haddocks, in particular, proved to be exceptionally delicate as compared

with the codlings and whittings, and most of them died at one time or other during the course of the experiments. They did not appear to make themselves at home, so to speak, as the codlings and the whittings did, and they were obviously, under the conditions of the experiment, more stupid fish. When the fish were fed the chopped mussels were dropped gradually into the water, and the moment the fragments began to sink the whittings and codlings rushed at them and, even when replete of a previous meal, took them into their mouths and put them out again, or smelt them; their movements were thoroughly purposive in relation to the food. The haddocks, on the other hand, excited by the commotion, or it may be by the odour of the mussels also, rushed aimlessly about at such times, snapping at the other fishes and missing the fragments although often quite near them and themselves quite hungry. The haddocks, it was also noticed, kept closer to the bottom, and looked for their food there rather than in the course of descent through the water.*

The fact has to be taken into account, because, although food was supplied abundantly, it is pretty certain that the haddocks, as a rule, got only what the others left.

It is probable also that the haddocks suffered more than the other fishes from not getting a more natural food. With reference to temperature they were also more sensitive than the others. When the water got comparatively warm, say about 60° F., the haddocks first showed signs of distress and went round the tank near the top gasping or tried to jump out, and I attribute the deaths of most of the haddocks to this cause. On one occasion I transferred a haddock of 19.9cm. from water of a temperature of 7.4 C. (45.3 F.) to water of 15 C. (59 F.) and it was killed in about two minutes, as if it had been poisoned; it rapidly became paralysed, swayed about a few moments and then sank with its mouth open. A small whiting (15.0cm.) transferred at the same time appeared to be doing well, but was found dead the next morning. The haddocks, moreover, were observed to seek the coolest parts of the hot-water tank, while, unless when the temperature was very high, the whittings and codlings in that tank seemed to enjoy themselves and were active and alert. It may be said that at first the hot water was run in on the top, but it was found that there was a difference of two or three degrees under these circumstances between the surface and bottom water; thereafter it was carried towards the bottom by a pipe, arrangements being made for air passing in with the water at the same time and thus the temperature was nearly equalised.

During the cold weather in winter a great contrast was shown between the fishes in the warm tanks and those in the tanks where the temperature was low, the difference in temperature being about 9 C. In the former they moved about actively and were keen and alert and, if the expression may be used, were happy; in the cold water tanks the fish, on the other hand, were sluggish, remaining a long time at one spot, and gently swaying their fins: the movement and activity in the one tank offered a marked contrast to the comparative lifelessness in the adjoining tank. It has already been said that the fishes in the warm water had a far better appetite than those in the cold water and ate much more; it was, moreover, observed that at times when the temperature was low, down to about 3.8 C., or a little above the freezing point of fresh water, the fishes in these tanks gave up feeding altogether, while in the adjoining heated tanks the fish were fighting eagerly for the food. In the former at such times the mussels would be left untouched at the bottom of the tank. This confirms

* It may be here stated that the haddocks, as a rule, swam nearer the bottom than the codlings or the whittings, and this was especially noticeable at first when the fishes were introduced into the tanks. While the haddocks grovelled about the bottom, the whittings were dispersed upwards to near the top of the tank. The observation as to the difference in habit may have reference to the fact that whittings and codlings are caught in far greater proportions than haddocks by the otter-trawl compared with the beam-trawl

my experience at Dunbar in former years, when it was found that plaice and dabs kept in small tanks lost weight in winter and gave up feeding.*

In tank No. 1, which contained as we have seen about 185·5 gallons (842·5 litres), seven whittings, five codlings, one haddock, one common dab, and one sand-eel were placed; the latter soon disappeared, and was probably eaten. The fish were measured on two occasions, (1) at an interval of 100 days, and (2) after 155 days. It would, as it turned out, have been better to have measured them more frequently, since, with the exception of the sand-eel, all the fishes survived in this tank; but from the mortality in the other tanks it was deemed advisable to disturb them as little as possible. In measuring them, they were first transferred to convenient dishes, seized cautiously with a loose cloth, and when laid on the measuring board care was taken to free the under surface of the fish from the cloth. A little practice made the process easy, the only forms requiring extra care and promptness being the haddocks. In the accompanying Table I give the particulars regarding these fourteen fishes which were kept in water at the ordinary temperatures.

TANK I.

FISH.	Length.	Mean Temperature 4·5° C. (40·1° F.).			Mean Temperature 9·3° C. (48·7° F.).			Mean Temp. 6·5° C. (43·7° F.).	
		100 Days Later.			55 Days Later.			Increase in the 155 Days.	
		Length.	Increase.		Length.	Increase.		Total.	Mean per 10 Days.
			Total.	Mean per 10 Days.		Total.	Mean per 10 Days.		
Whiting.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.
1	209	226	17	1·7	244	18	3·27	35	2·28
2	170	191	21	2·1	210	19	3·45	40	2·58
3	160	173	13	1·3	187	14	2·18	27	1·74
4	157	172	15	1·5	181	9	1·64	24	1·55
5	152	169	17	1·7	178	9	1·64	26	1·68
6	152	164	12	1·2	177	13	2·36	25	1·61
7	142	159	17	1·7	174	15	2·73	32	2·06
Average,	163·14	179·14	16	1·6	193·0	13·86	2·52	29·86	1·93
Codling.									
1	147	185	38	3·8	226	41	7·45	79	5·1
2	[143	184	41	4·1	200	16	2·9	57	3·7
3	132	169	37	3·7	208	39	7·09	79	4·9
4	129	163	34	3·4	200	37	6·73	71	4·58
5	123	160	37	3·7	194	34	6·18	71	4·58
Average, {	134·8	172·2	37·4	3·74	...	...	...	...	...
	132·7	169·2	36·5	3·65	207	37·8	6·87	75·7	4·88
Haddock.	183	210	27	2·7	238	28	5·1	55·0	3·55
Common Dab.	237	243	6	0·6	243	0·0	...	6	0·04

* *Eleventh Annual Report Fishery Board for Scotland, Part III., p. 193.*

Among the seven whittings the growth in the first hundred days when the mean temperature was 4.5 C. (40.1 F.) was not great, the increase in different fishes, as will be seen from the Table, varying from 12 to 21mm., the mean increase being 16mm., and the mean for each ten days on the average being 1.6 mm. The fishes were of different sizes as shown, and the increase per ten-day period varied from 1.2 to 2.1 mm. In the succeeding 55 days when the mean temperature of the water was 9.3 C. (48.7 F.) the actual increment of length in different fishes ranged from 9mm. to 19mm., the mean per ten days ranging from 1.64 to 3.45mm. The average increment was 13.86mm. and the mean for the lot per ten-day period was 2.52mm. Over the whole period of 155 days, the mean temperature being 6.5 C. (43.7 F.), the actual increments varied from 24mm. to 40mm. (from about one inch to an inch and nine sixteenths) the mean increase was 29.86mm., or about $1\frac{3}{8}$ inches, and for the ten-day period the mean increase was 1.93mm. There is no doubt that the greatest amount of growth was in the latter part of the second period, when the temperature was highest; at this time it was a common remark how fast the fish were growing, but for the reason above stated they were not more frequently measured. The whittings, it may be said, appeared to be in good condition and health.

The codlings grew more rapidly than the whittings. One of them (No. 2) which grew fastest during the first period developed a diseased growth or tumour in the second period when its rate of increase was therefore very slow. It has been accordingly left out of the calculations of the means in the second period, and the other four fishes have been also dealt with separately throughout. In the first hundred days the increments varied from 34 to 41mm. ($1\frac{3}{8}$ to $1\frac{5}{8}$ inches), the means for the ten days being from 3.4 to 4.1mm.; the mean increase was 37.4mm., and the ten days' mean 3.74mm. In the second period of fifty-five days the actual amount of growth was a little greater, so that under the difference of temperature indicated the codlings grew about twice more rapidly. Omitting the diseased fish the increments varied from 34 to 41mm.—precisely the same as in the first period—the average was 37.8mm. and the mean for 10 days 6.87mm. Over the whole time of 155 days the amount of growth in the four healthy fishes was respectively 79, 79, 71, 71mm., the average being 75.7mm., or about $3\frac{1}{8}$ inches—a very considerable rate considering the temperature of the water. On the other hand the fishes were supplied with abundance of food, and the codlings were the greediest of them all, and no doubt got more food in a given time than they would under natural conditions in the sea. With the exception of the one referred to they all remained healthy throughout the experiment.

The growth of the single haddock was also fairly rapid for the temperature. In the first hundred days its increase amounted to 27mm., or a little over an inch, the mean for ten days being 2.7. In the second period, like the codlings, the actual growth was about the same, although the time was only about half; it amounted to 28mm. ($1\frac{1}{8}$ inch), the ten-day mean being 5.1mm. Over the whole period the actual increase in length was 55mm. ($2\frac{3}{8}$ inches), the average for the ten-day period being 3.55mm.

The growth of the single common dab in this tank was slow and presented a contrast to the round fishes; it was an adult female. The increase in the first period was only 6mm. ($\frac{7}{8}$ inch), the mean for ten days being 0.6mm. In the second period it did not increase at all. Two circumstances may have affected this, the first that four spawning flounders were put into this tank early in the second period, and it is possible that the greater competition for food prevented the dab getting

a full share ; the second that it was a female of adult size and may have spawned. It was unfortunately omitted to provide apparatus in the overflow from the tank to obtain evidence as to this.

The observations in Tank No. 1 refer to growth under the ordinary temperature of the season.

TANK II.

Fish.	Length.	MEAN TEMPERATURE 5·2° C. (41·4° F.).			MEAN TEMPERATURE, 9·2° C. (48·6° F.).			MEAN TEMP., 7° C. (44·6° F.).	
		100 Days Later.			55 Days Later.			Increase in the 155 Days.	
		Length.	Increase.		Length.	Increase.		Total.	Mean per 10 Days.
			Total.	Mean per 10 Days.		Total.	Mean per 10 Days.		
Whittings.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.
1	179	193	14	1·4	207	14	2·54	28	1·81
2	178	192	14	1·4	202	10	1·82	24	1·55
3	170	185	15	1·5	196	11	2·0	26	1·68
4	160	179	19	1·9	192	13	2·36	32	2·06
5	151	173	22	2·2	187	14	2·54	36	2·32
6	151	171	20	2·0	184	13	2·36	33	2·13
7	148	164	16	1·6	181	17	3·09	33	2·13
8	145	160	15	1·5	177	17	3·09	32	2·06
9	140	159	19	1·9	176	17	3·09	36	2·32
10	138	158	20	2·0	171	13	2·36	33	2·13
11	134	154	20	2·0	170	16	2·91	36	2·32
12	134	152	18	1·8	164	12	2·18	30	1·93
13	[131	151	20	2·0	154	3	·5	23	-]
14	[130	150	20	2·0]	-	-	-	-	-
15	[109	128	19	1·9]	-	-	-	-	-
Average -	152·3	170·0	17·7	1·77	184·0	14·0	2·55	31·7	2·04
Haddock.									
1	193	211	18	1·8	-	-	-	-	-
2	180	199	19	1·9	-	-	-	-	-
3	178	197	19	1·9	-	-	-	-	-
Average, -	183·7	202·3	18·6	1·86	-	-	-	-	-
Com. Dab.									
1	241	248	7	0·7	251	3	·55	10	·07
2	146	168	22	2·2	190	22	4·0	44	2·84
Average, -	193·5	208	14·5	1·45	220·5	12·5	2·27	26	1·68
Starry Ray.	198	198	0·0	-	195	-3	-	-3	-

The same is true of Tank No. 2, except, as formerly explained, the temperature here was generally slightly higher owing to its being nearer the stove. Into this tank were placed fifteen whittings, three haddocks, two common dabs, and a starry ray; a sand-eel was also present at first, but, as in the other tank, it soon disappeared. The particulars of these fishes are given in the accompanying Table. Three of the whittings are not included in the final column and averages; No. 13 was found in the second period to have the tail and one of the eyes diseased, and its growth had been thus interfered with, No. 14 was transferred to the warm tank as already described, and No. 15 was found dead when thirty-five days of the second period had elapsed, and it then measured 134mm. In the first hundred days, with a mean temperature of 5·2 C., the increments varied from 14 to 22mm., the mean being 17·7mm., or 1·7mm. above that for Tank No. 1, a difference probably related to the somewhat higher mean temperature (·7 C.). As a rule the greatest increase was among the smaller fishes. In the second period of 55 days, with a mean temperature of 9·2 C. (48·6 F.), the increments ranged in different cases from 10 to 17mm., and the mean was 14mm., as compared with 13·86 in Tank No. 1, the mean for ten days being 2·55, as compared with 2·52—almost precisely the same. It will be seen from the tables that the mean temperature of the two tanks in the second period were also practically identical, differing by only ·1 C., but the difference was in favour of Tank No. 1, into which the sunshine entered more freely.

The haddocks did not thrive so well compared with the one in Tank No. 1, and they all died early in the second period. The mean increment in the hundred days was 18·6mm., as compared with 27mm. in Tank No. 1, the mean for the ten days being 1·86mm. against 2·7mm. One of these haddocks, 199mm. long, perished by being placed in warmer water as previously described; it was well nourished, its weight being 67·5 grammes, while the mean weight of haddocks of the same size is 65·7 grammes (see Table, p. 226). One of the others died 18 days after the measurement recorded, and it was then 216mm. long, an increase of 5m.

Of the two common dabs, the smaller grew quickly and the larger slowly. In the first period the former increased by 22m. and the latter by only 7mm.; in the second period the smaller increased by 22m. again, and the larger by only 3mm., the growth as with the round fishes being about twice quicker in the higher temperature of the second period. The small one increased in the hundred days by 44mm., or $1\frac{1}{4}$ inches, the mean rate being 2·84mm. per ten days, while the increase of the larger one amounted in the 155 days to only 10mm., or $\frac{3}{8}$ of an inch, the mean for ten days being only 0·07mm. They were both females.

The starry ray did not grow at all; during the first period it just maintained its breadth, and in the second it lost about 3mm. in the same dimension. Its loss of weight must have been relatively greater because it became very attenuated, and it was no doubt owing to lack of proper food.

In Tank No. 3 an endeavour was made to maintain a temperature intermediate between that of Tanks Nos. 1 and 2 and Tank No. 4, but as previously mentioned the variations were considerable, and the results in this tank were not so satisfactory. It appears moreover probable that in the endeavours to adjust the supply of hot and cold water the circulation was diminished. For some reason or another four of the whittings and five of the codlings put in died a short time after the experiment was begun, and these are not included in the accompanying Table, which gives the particulars regarding the rest of the fish. Two haddocks which were placed in the tank also died; the autopsy revealed no apparent

cause of death, which was possibly due to the variations in the temperature of the water, but one of them, 202mm. in length, which should have weighed about 67 grammes, weighed only 63·8 grammes.

TANK III.

FISH.	Length.	MEAN TEMPERATURE, 7·7° C. (45·9° F.).			MEAN TEMPERATURE, 10·3° C. (50·5° F.).			MEAN TEMP., 8·6° C. (47·5° F.).	
		100 Days Later.			55 Days Later.			Increase in the 155 Days.	
		Length.	Increase.		Length.	Increase.		Total.	Mean per 10 Days.
			Total.	Mean per 10 Days.		Total.	Mean per 10 Days.		
Whiting.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.
1	162	186	24	2·4	204	18	3·27	42	2·71
2	160	180	20	2·0	190	10	1·82	30	1·93
3	153	176	23	2·3	188	12	2·18	35	2·26
4	152	170	18	1·8	185	15	2·73	33	2·13
5	[147	158	11]	...	...	...	...	...	...
6	[146	155	9]	...	...	...	...	...	...
Average,	156·7	178	21·3	2·13	191·7	13·7	2·49	35	2·26
Codling.									
1	161	209	48	4·8	256	47	8·54	95	6·13
2	158	198	40	4·0	246	48	8·73	88	5·68
3	141	168	27	2·7	212	44	8·00	71	4·58
4	135	163	28	2·8	210	47	8·54	75	4·84
5	128	158	30	3·0	194	36	6·55	66	4·26
6	113	137	24	2·4	148	11	2·0	35	2·26
7	[149	189	40	4·0	...	...	...	...	...
Average, {	140·7	174·6	33·9	3·39	...	...	...	...	...
	139·3	172·2	32·9	3·29	211	38·8	7·05	71·7	4·63
Common Dab.	261	276	15	1·5	286	10	1·82	25	1·61

The particulars in regard to the whiting show that the increment in the first period varied from 9mm. to 24mm., but the fish showing the small increase and another showing an increase of only 11m., were found to have the tail badly ulcerated and they were killed. Omitting these two, the mean increase was 21·3mm., or an average per ten days of 2·13mm. as compared with 16mm. and 17·7mm. in the cold tanks. In the second period the increase was on an average 13·7mm., and therefore under the average for the cold water tanks in the same period, which shows, as well

as the mortality alluded to, that the conditions in this tank were not satisfactory. The mean increase over the whole period was 35mm., or $1\frac{3}{8}$ inches, the ten-day mean 2.26mm., a little higher than that for the two tanks referred to in the similar period.

Among the cod the increase ranged in the first period from 24mm. to 48mm., the average mean being 33.9mm., and the ten-day mean 3.39mm., and therefore a little less than Tank No. 1. One of the codlings, No. 7, was transferred to Tank No. 4 after this, and died four days later, like the haddock and whiting above mentioned; in this case the interval was longer. In the second period the remaining fishes increased from 11mm. to 48mm. in different cases, the average being 38.8mm., or about $1\frac{1}{2}$ inches. Omitting the smaller specimen, in which the increase was clearly anomalous, the average increase of the others was 44.4mm., or 8.1 per ten days. The increments in the length over the whole time varied from 35mm. to 95mm., the mean increase being 71.7mm., or omitting the anomalous form, 79mm., or $3\frac{1}{8}$ inches, the mean for ten days being 5.1mm.

The single common dab in this tank increased by 15mm. in the first period and by 10mm. in the second, the increment over the whole time being 25mm., or 1 inch, and the average per 10 days 1.61mm.

In tank No. 4 there was at first some mortality owing to the vicissitudes in the temperature which, as already stated, affected different fishes in different ways.

Of three haddocks put in none survived the whole period, and only one the first. One died after fifteen days; it was 285mm. and had increased to 287mm. Another died after eighty-three days, and it had increased from 279 to 295mm. The third at the end of the first period increased from 262 to 279mm., an increment of 17mm., the average per ten days being the small one of 1.7mm. It died from the high temperature a few days later without having increased in length.

Among the whittings there was less mortality, nine surviving the whole time and other two for the first period. In the first hundred days the variations in the increase were from 19mm. to 34mm., the mean being 27.5mm., or a little over an inch, the ten-day mean averaging 2.74mm. In the second period the increments ranged from 9mm. to 19mm., the mean being 15.7mm. and the average of the ten-day mean 2.85mm.

Over the whole period the increments varied from 28mm. to 52mm., the mean being 43.1mm., about $1\frac{3}{4}$ inches, the mean increase in the ten-day periods being 2.79mm.

| TABLE.

TANK IV.

Fish.	Length.	MEAN TEMPERATURE, 12·3° C. (54·1° F.).			MEAN TEMPERATURE, 12·9° C. (55·2° F.).			MEAN TEMP. 12·5° C. (54·5° F.).	
		100 Days later.			55 Days later.			Increase in the 155 Days.	
		Length.	Increase.		Length.	Increase.		Total.	Mean per 10 Days.
			Total.	Mean per 10 Days.		Total.	Mean per 10 Days.		
Whiting.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.
1	241	260	19	1·9	269	9	1·64	28	1·81
2	208	229	21	2·1	242	13	2·36	34	2·19
3	204	225	21	2·1	239	14	2·54	35	2·26
4	177	203	26	2·6	220	17	3·00	43	2·77
5	161	193	32	3·2	209	16	2·91	48	3·09
6	157	186	29	2·9	204	18	3·27	47	3·03
7	146	180	34	3·4	197	18	3·27	52	3·36
8	140	171	31	3·1	190	19	3·45	50	3·22
9	140	174	34	3·4	192	18	3·27	52	3·36
10	164	192	28	2·8	—	—	—	—	—
11	158	186	28	2·8	—	—	—	—	—
Average, {	172·4	199·9	27·5	2·75	—	—	—	—	—
	174·9	202·3	27·4	2·74	218	15·7	2·85	43·1	2·79
Codling.									
1	173	225	52	5·2	278	53	9·64	105	6·77
2	126	167	41	4·1	221	54	9·82	95	6·13
3	120	166	46	4·6	220	54	9·82	100	6·45
Average,	139·7	186	46·3	4·63	239·7	53·7	9·76	100	6·45
Com. Dab.									
1	245	262	17	1·7	276	14	2·55	31	2·0
2	151	186	35	3·5	207	21	3·82	56	3·61
3	147	185	38	3·8	202	17	3·09	55	3·55
4	—	206	—	—	237	31	5·64	—	—
Average,	181	211	30	3·0	228·3	17·3	3·15	47·3	3·05
Plaice,	226	258	32	3·2	277	19	3·45	51	3·29
Pogge,	127	127	—	—	—	—	—	—	—

It will be noticed from the Table that the increments of growth were much greater in the smaller forms than in the larger.

As in all the other tanks, the codlings grew rapidly. In the first hundred days the increments varied from 41mm. to 52mm., the mean being 46.3, and the mean for the ten-day periods was 4.63. In the second the increase ranged from 53 to 54mm., the increments being thus absolutely larger though the period was less and the mean temperature not much higher. The mean increase was 53.7mm., that for the ten-day period being 9.76mm. The total increase in length in the three specimens in the 155 days was respectively, 105mm., 95mm., and 100mm., the mean being exactly 100mm., or very close upon 4 inches, and the mean for the ten-day periods was 6.45mm. Of all the fishes, except the flat-fishes, the codlings appeared to be least affected by the changes in the temperature.

In this tank there were throughout three dabs and one plaice, and another dab was added at the beginning of the second period. They did well, as a rule. In the first period the increments among the dabs ranged from 17mm. to 38mm., the mean increase being 30mm., or a little over $1\frac{1}{8}$ inches, the mean for the ten days being 3.0mm. In the second period the increments varied from 14 to 31mm., the mean increase was 17.3mm., and the mean for the ten days, 3.15mm. Over the whole period the increments of the dabs in this tank varied from 31 to 56mm. ($1\frac{1}{4}$ to $2\frac{1}{4}$ inches), the average being 47.3mm., and that for the ten days, 3.05mm.

Only one plaice was made use of, and it increased in the first period from 226 to 258mm., an increment of 32mm., or a little over $1\frac{1}{4}$ inches. In the second period it increased other 19mm., the ten-day mean being 3.45mm., as compared with 3.2mm. in the first period. The total increase at the end of the experiment was 51mm., giving an average for the ten days of 3.29mm.

It may be noted that throughout the whole of the experiment none of the flat-fishes perished, so that they bore the changes in temperature much better than the round fishes.

An armed-bullhead, or pogge, was also placed in this tank, and survived over the first period, but it did not increase in length at all. Probably like the starry ray this was owing to the food not being quite suitable for it. It died shortly after the beginning of the second period, on one occasion when the temperature rose high.

These experiments show that the increase in temperature is followed by an increased rate of growth, but I do not think the data are such as to enable the ratio between the two to be determined. In such experiments there are a number of factors which influence the growth, and it is a matter of extreme difficulty to maintain a natural balance among them in the various tanks, and to have the experiments carried on under natural conditions. The influence of the vicissitudes in the temperature at different times of the day or night must be of importance, as shown by the experiments of putting fishes from the cold water into the warm water, the haddock, whiting, and codling all perishing, although at very different intervals. In order to get a more precise relation between the temperature and the growth it would be necessary to maintain the temperature nearly uniform in each of the tanks throughout, or at all events to reduce very greatly the rapidity of the alterations. The question of food is also one that would, in any circumstances, give rise to difficulty, and yet it is evidently one of much importance. It is not easy procuring the natural food of the fishes and supplying it in due proportions.

It appears that the influence of temperature is active in modifying the rate of growth by acting directly upon the metabolism of the fish, and

also by affecting the rapidity of digestion. In very cold water the fishes give up feeding altogether, because the ferments upon which digestion depends do not act, or act very slowly, at low temperatures, and in fishes, as in other animals, appetite waits on digestion, and this is, on the other hand, correlated with the metabolism in the tissues. It has been shown by Krukenberg that the pepsine or analagous body in the stomach of fish acts as well at 20 C. as at 40 C., at which, among mammals, digestion is most active, and that the rapidity of its action is closely related to the temperature; and Knauth and Zuntz have shown that the same thing applies to the metabolism in fish, the vital activities being more active in the higher temperature, as shown by the excretion of carbonic acid gas and other products of metabolism.

5. THE SPRAT (*Clupea sprattus*).

Comparatively few observations have been made on the rate of growth of the sprat. Cunningham appears to have been the first to publish a definite statement on the subject,* making use of a number of observations of Ewart and Matthews, contained in a paper on the nature of Thames and Forth whitebait, which appeared in the Fourth Annual Report of the Fishery Board for Scotland.† In that paper an account was given of the proportion of herrings and sprats, and their sizes, in collections obtained at different times of the year from February to August, and from a study of these Cunningham came to the conclusion that the little sprats two to three inches long obtained in February, March, April, and May were about one year old. The new brood of the year began to appear in the whitebait in June and increased to August, when they measured from 1 inch to 1½ inch (25-38mm.). The proportion of sprats in the samples in this month was 48 per cent., but the number of the small scaleless sprats gradually increased during the month until 90 per cent. consisted of these. Of 2600 specimens of whitebait procured in samples of about two hundred each during December, January, and February in the Firth of Forth, over 99½ per cent. were sprats measuring from 1½ inches to 2¾ inches (35 to 70mm.). In the samples from the Thames the average size was 2 inches (50mm) in April, and 2½ inches in May.

From the examination of the otoliths of a considerable number of sprats, partly from the North Sea and partly from the Baltic, Jenkins came to the conclusion that the growth was somewhat more rapid. He assigns a length of 75mm. (3 inches) to the sprat one year old; of 110mm. (4¾ inches) to the sprat which has completed two years, and of 130mm. (5½ inches) to the sprat three years old.‡

The investigations made by myself on the rate of growth of the sprat, and described in this paper, were on material collected almost entirely in the course of the trawling investigations in the Moray Firth and Aberdeen Bay by means of a small-meshed net placed outside the cod-end of the trawl net; but some of them were obtained by the shrimp-net and tow-nets. The fact has to be kept in mind, because apart from the difference in vertical distribution at different stages, which might result in sprats of different size being taken in the bottom or surface net at the same time, the size of the mesh exerts an important influence on the sizes of the samples taken, at least as far as the smaller specimens are concerned, and there is no doubt that in several of my collections the very small slender sprats

* *Journ. Marine Biol. Assoc. II.* p. 241, 1892; "Marketable Marine Fishes," p. 167.

† P. 98, 1886.

‡ *Wissensch. Meeresuntersuch. Kiel N.F. Bd. 6 Abtheilung*, Kiel, p. 111, 1902.

escaped capture either wholly or largely by passing out through the meshes of the net, although they may have been present in the water in considerable numbers. This, however, does not entirely account for the fact which is apparent from the measurements in the tables and from the curves, that it was the rule to get only one series of sprats, with a certain range of sizes, in the same haul, while in another haul in the same locality later, or at the same time in another place, quite a different series predominated. That seems to be due to the sprats of different years keeping for the most part separate from one another.

The number of collections obtained and examined was twenty-six, some in each month of the year except February, July, and August; most of them were obtained in October and December.

From the fact that the spawning period of the sprat is definitely limited to one portion of the year it is more easy to determine its rate of growth than in the case of the herring, in which there are two well separated spawning seasons, spring and autumn, and a certain degree of spawning in the intermediate periods. The sprat appears to spawn at different parts of the coast at rather different times, or at all events the spawning period does not quite coincide. At Plymouth, Cunningham found it spawning from the end of January until the end of April, or even later.* On the west coast of Ireland Holt obtained the floating eggs in March, April, May, and June; chiefly in March and April.† Hensen and Apstein give the spawning period as the end of April and the beginning of May.‡ On the east coast of Scotland the *Garland* found the floating eggs in the Firth of Forth from towards the end of March to the middle of August, and especially in April, May, and June. In the Moray Firth I found sprats to be spawning on the 1st April and 1st June; and though the limits of the period here are not well defined, there is no reason to doubt that they are much the same as a little further down the coast, and probably the chief spawning occurs about the end of May on this stretch of coast.

From the small size of the egg and the temperature of the water at that season the hatching of the eggs takes only a few days, the length of the larva, according to Cunningham, being from 3 to 3·7mm. Probably the early part of June may therefore be taken as the period when the bulk of the larval sprats issue into the water.

The smallest specimens got after the spawning season were obtained in September and October in Aberdeen Bay and in the Moray Firth in December, in all cases by the tow-net. On the 18th September, near shore, in from seven to ten feet of water in Aberdeen Bay, sixteen were taken from 29mm. to 46mm., and on the 20th other five measuring from 29mm. to 39mm., the average size of these twenty-one specimens being 35·9mm., or $1\frac{5}{8}$ inches. On 18th October, in nine fathoms, in the same locality, four were caught which measured 31, 35, 42, and 45mm. On the 28th December in the Dornoch Firth two were taken in the tow-nets, one of which measured 39mm. and the other 48mm., while 734 were caught in the small-meshed net around the cod-end, ranging in size from 52 to 125mm. It is obvious that all the small sprats taken in these drags had been hatched in the previous spawning season, and were approximately from three to six months old.

In April, some small sprats were also got in the shrimp net in shallow water in Aberdeen Bay. On the 8th of the month three were taken which measured 45, 50, and 53mm., as well as a number from 65mm. upwards. On the 16th of the month other fifty-one were taken with the

* "The Natural History of the Marketable Marine Fishes," p. 165.

† *Rep. of Council, Roy. Dublin Soc. for 1891*, p. 265.

‡ *Wissen. Meeresuntersuch.* Kiel Commis. Neue Folge, Bd. 2 Heft 2, p. 37.

shrimp-net in the same locality, measuring from 40 to 70mm., but all except four were less than 55mm., these being—one at 56mm., two at 65mm., and one at 70mm. From the curves for the whole of the sprats in these collections it is apparent that the last and possibly those at 62mm. belong to the second group. The average size of the fifty-four sprats assigned to the first series was 48·3mm., or $1\frac{7}{8}$ inches, including the two at 62mm., and the mean size, *i.e.*, coinciding with the central point of the base line from the smallest to the largest, is also 48mm. This might appear to be the size of sprats ten or eleven months old, belonging to the previous spawning season, and it is considerably under the size assigned by Jenkins to those of one year's growth, although the amount of growth from the middle of April to the early part of June, the period I have taken as representing the maximum of hatching, would add several mm. to their length. The average agrees better with the size of the sprats from the Thames in April examined by Matthews, *viz.*, two inches. On 12th December, however, four months earlier, a haul with the small-meshed net in the same locality in from eight to twelve fathoms furnished seventy-four sprats, of which the first series numbered forty-seven, ranging in size from 49mm. to 60mm., the average being 55·5mm., and the mean 54·5mm. This shows that the collection in April was not fully representative of the series. By combining the two collections the average size of the 98 sprats of this series is found to be 51·3mm., or 2 inches—the range in size being from 40mm. to 60mm., and the mean size 50mm. The date intermediate between the collections is about 14th February, and the size stated may be taken as approximately representing the average size of the sprats at this date. Growth is slow at this time of year and on to April, and an examination of the other curves shows that the end of the first series is about 6cm. when the sprats are about one year old, the average size being a little over 50mm., or slightly over 2 inches.

There was no collection in February, and that made at the end of March in the Dornoch Firth did not include any of the smaller forms. In St. Andrews Bay M'Intosh obtained sprats on 12th March in the bottom trawl-tow-net, measuring from $1\frac{1}{4}$ to 2 inches (32 - 50mm.); and on 12th April one 2 inches long, and floating eggs of the sprat two days later.*

The older series are present in the collections in greater numbers, but as is usually the case it is frequently a matter of difficulty to fix exactly the point of division between them, owing to the overlapping of one series with another and often the small numbers of the fish of one of the series.

Taking the hauls in the order of the months, the first was on 15th January off Aberdeen, and of sixteen sprats obtained three belonged to one series with an average size of 87 mm., and the other thirteen ranged in size from 112 to 135mm. The larger of these probably belonged to a still older series., but the average for the lot was 123 mm. Another haul in January in the Cromarty Firth furnished twenty-seven sprats, of which twenty-three, measuring from 61 to 92mm., formed one series with an average size of 77·2mm., and the other four belonged to the older group, measuring from 111 to 117mm., and with an average of 114mm.

If these two January hauls are combined the first group, with a range from 61 to 92mm., has an average size of 78·3mm., and the second, with a range of from 111 to 135mm., an average of 120·9mm.

No collection was made in February, but on 31st March 870 were taken in the Dornoch Firth. Of these, 205 ranged in length from 75 to 107 mm., the average being 96·8mm.; and the other 665 formed a series from 108 to 139mm., with an average of 117·8mm. The latter series of sprats were ripe and approaching ripeness.

In April the collection in Aberdeen Bay, besides the fifty-four small

* *Eleventh Ann. Rep. Fishery Board for Scotland*, Part iii., p. 300.

ones above described, was made up of another series of fifty-four, ranging from 68 to 107mm. and with an average size of 81.5mm. There was also one sprat at 116mm., which appeared to belong to another series. In a haul of the small-meshed net made off Burghead Bay in the Moray Firth in thirty fathoms of water on 1st April seventy-four sprats were caught, two of which measured 101 and 104mm., and the others from 108 to 126mm., the average size being 118.1mm. This collection is of special interest from the fact that the sprats were spawning, as referred to below.

In May there was only one collection of sprats and it was from the Firth of Forth, where a number were taken on the ninth of the month at Station III. by means of the small-meshed net around the cod-end of the *Garland's* trawl. There were two small ones, one measuring 52mm. and the other 62mm. and it appears that these belong to the group of smallest sprats, most of which were able to escape through the meshes of the net, that is, the group about one year old. The next series was well represented, the sprats numbering 554, and ranging in size from 68 to 110mm. The average size was 83.4mm. Thirteen larger fishes pertained to an older group, measuring from 113 to 134mm., and having an average of 120.9mm.

Two hauls were made on 1st June, one in the Cromarty Firth and the other at Aberdeen. At Cromarty the sprats were found to be spawning, and with the exception of one, 124mm. in length, they seemed all to belong to the same series. The range of size was from 73 to 110mm., the average being 92.9mm.

In the collection from Aberdeen Bay the corresponding series was represented by fifty-seven fish measuring from 86 to 109mm., the average length being 96.5mm., and there was a larger one at 116mm.

On the 28th of the month eighty-one were taken at Lunan Bay near Montrose, further down the coast, and they all belonged to the same group, the range of sizes being from 86 to 117mm., with an average of 104.2mm.

When the measurements of all the sprats obtained in June are combined the following result is obtained. The first is represented by the two fishes from the Forth, 52 and 62mm.; the second consists of 689 sprats, ranging in size from 68 to 117mm. with an average of 94.4mm.; and the third by two fishes with an average of 120mm.

From the end of June to the middle of October no collections were procured with the exception of the twenty-one small ones got in the tow-nets on 18th and 20th September.

On the 18th and 20th October a number were taken in Aberdeen Bay. Four of these measured from 31 to 45mm. and have been already referred to; of the others, fifteen, ranging in size from 82 to 94mm., had an average size of 86.8mm., and ninety-two ranged from 107 to 130mm., the average being 114.5mm. On the 22nd, forty-three were caught in the Dornoch Firth, one measuring 54mm. belonging to the early group; sixteen varied from 65 to 96mm., with an average of 81.7mm., and twenty-six from 100 to 124mm., the average being 114.6. These October series when combined give three groups, one from 31 to 54mm., with an average of 41.4mm., one from 65 to 96mm., with an average of 84.1mm., and a third from 100 to 130mm., with an average of 114.5mm. The number of fishes in the first was five, in the second thirty-one, and in the third 118. It may be here said that the average of the second series is higher than it ought to be, but the number of fishes in it is small.

In November a collection was obtained in the Dornoch Firth, all three series being represented. The first consisted of thirty-three fishes measuring from 45 to 61mm., with an average of 55.6mm. The second series was predominant, the number of sprats measured being 1650. They ranged in sizes from 62 to 98mm., with an average of 75.5mm.

There were also nine sprats varying from 102 to 112mm. A collection at Aberdeen on the 28th furnished fourteen sprats; one measured 87mm., and the other thirteen ranged from 113 to 125mm., the average being 120·2. The average of the twenty-two of the third series in the two hauls combined was 114·4mm.

In December a number of collections were obtained from the Moray Firth and Aberdeen Bay. In the latter, on the twelfth of the month, seventy-three were procured belonging to three series. The first comprised forty-seven fishes, the sizes of which ranged from 49 to 60mm. with an average of 55·5mm.; the second included twenty-four from 62 to 97mm. the average being 77·6mm., and there were other two measuring 101 and 102mm. On the 18th, twenty-six were obtained, of which twenty-two, measuring from 66 to 84mm., had an average size of 73·7mm., and four, ranging from 100 to 132mm., an average of 111·7mm. On the 19th, seventy-four were secured, seventy of them belonging to the second series, ranging in size from 67 to 97mm., the average being 78·7mm.; the other four measured from 104 to 111mm., with an average of 107·5mm. On the 29th, thirty-nine were taken, all belonging to the third group, the sizes varying from 98 to 128mm., and the average being 111·1mm.

A collection made in the Dornoch Firth on the 25th of the month numbered 184 fishes, all of which except sixteen belonged to the second group. They ranged in size from 72 to 98mm., the average being 86·6mm.; the other sixteen measured from 103 to 122mm., the average being 112·1mm. In a collection made on the 27th, three groups were represented; the first, comprising three fishes, had an average of 57·7mm.; the second, ranging from 63 to 97mm., and including thirty-six fishes, had an average size of 76·6mm.; the third, of fifty-four fishes, had a range of from 100 to 127mm., and an average size of 107·8mm. On the 28th a third collection numbering 722 sprats contained three series. The first, nineteen in number, ranged in size from 39 to 60mm., the average being 59·2mm. The second series comprised 575 fishes, the sizes varying from 62 to 97mm., and the average size being 79·5mm. The third series of 128 fishes ranged in size from 98 to 128mm., and the average was 109·7mm.

The larger or older group was well represented in a haul made in Burghead Bay on the 25th December. Of 536 sprats caught 520 belonged to that group, their sizes ranging from 97 to 138mm., and the average being 121·1mm. On the 28th another haul yielded a large number, the second series being the best represented on this occasion. The first group contained twenty-five fishes varying from 50 to 61mm., with an average of 55·8mm.; the second comprised 436 sprats from 63 to 91mm., and with an average of 75·2mm.; and the third series of twenty-seven ranged from 96 to 124mm., the average being 116·0mm.

When all the collections made in December are combined we have the following general results. The first series of ninety-four fish ranged in size from 39 to 60mm., the average being 55·8mm.; the second group of 1347 fishes varied in size from 62 to 97mm., and had an average size of 79·5mm.; and the third series, numbering 794 fishes, had an average size of 117·4mm., and a range from 98 to 138mm. It is probable that the larger forms in the third series belong to a still older group, but their members are so small and the difficulty of dividing them from the series immediately preceding so great that I have not attempted to group them into a fourth series. This circumstance will to a small extent raise the average of the third series higher than it naturally ought to be. It must also be said that the range assigned to the various groups may not be in all cases the precise one that exists, for it is sometimes very difficult to define the division between the series. In such cases the curves and tables of millimetre measurements must be the best guide.

It is clear, however, from the measurements that at least three annual series or groups of sprats exist in these collections, although they are rarely well represented together in any one collection, and this is obvious from the curves in the plates, and especially from the curve for the combined measurements in December (fig. 10, Pl. IX).

The first or early series has been already alluded to, and the facts show that the sprat grows slowly.

Three collections were made in which spawning sprats were got, one on the 1st April, off Burghead, one on the 1st June in the Uromarty Firth, and the third on 31st March in the Dornoch Firth. In the first named collection the seventy-two sprats forming the second series measured, as stated, from 108 to 126mm., with an average of 118·1mm. The initial sizes were as follows:—one at 101mm., one at 104mm., one at 108mm., and then the series was continuous from 110mm. onwards. Unfortunately, the condition of the reproductive organ was not examined throughout the whole series, but in eighteen males from 104mm. to 125mm. the testes were large and apparently ripe or approaching ripeness; they were examined after preservation in formaline solution. The number of female sprats examined was nineteen, varying in size from 110 to 126 mm., and they all contained either fully mature eggs or eggs approaching maturity. In those fully mature the germinal vesicle had disappeared and the yolk was translucent but still somewhat granular. It was noticed that there was not any indication of an external swelling of the belly such as is found as a rule in fishes with fully-developed reproductive organs, so that it was impossible to tell from the external examination whether the fishes were about to spawn or not. The number of the mature or nearly mature eggs was, moreover, very small compared with the number to be found in the ovaries of most other fishes with pelagic eggs—amounting only to a few thousands (*see* p. 285). I append a Table giving particulars of the weights (in grammes) and condition of the reproductive organs in some of those examined:—

MALES.			FEMALES.			
Size.	Weight.	Weight of Testes.	Size.	Weight.	Weight of Ovaries.	Condition of Eggs.
119	10·8	0·7	122	12·8	0·38	Largest yolked up to ·46 mm.
121	12·2	0·7	120	12·0	0·492	„ „ „ ·44 „
115	9·1	0·5	124	12·8	0·44	„ „ „ ·44 „
120	11·5	0·56	122	10·5	0·49	„ „ „ ·609 „
123	13·5	0·75	126	13·0	0·42	„ „ „ ·42 „
124	13	0·58	122	10·7	0·33	„ „ „ ·38 „
116	10·7	0·52	121	12·0	0·29	„ „ „ ·44 „
119	11·8	0·68	117	11·0	0·34	„ „ „ ·44 „
117	8·8	0·3	118	10·7	0·20	„ „ „ ·336 „
114	10·5	0·56	120	11·8	0·54	„ „ „ ·651 „
114	8·3	0·2	118	11·7	0·32	„ „ „ ·378 „
113	9·5	0·56	111	8·8	0·22	„ „ „ ·336 „
104	6·5	0·30	110	8·2	...	„ „ „ ·79 „

In the case of the sprats taken in the Cromarty Firth on 1st June, only a few were examined in regard to the reproductive organs, and I noted that the females over 104mm. were spawning, and males of the same size were also ripe, but it is possible that some under those sizes might also have been found ripe if a fuller examination had been made of them. The collection made on 31st March in the Dornoch Firth furnishes the best material, because a larger number of them were examined, the sexes determined, and the reproductive organs noted. Of the 870 obtained, 559 were males and 311 were females, and in some instances, males as small as 84mm. had testes sufficiently developed to indicate that they would probably spawn in the course of the season—at the close of which they would have considerably increased in length.

It was in this case, as in many others, difficult to divide the first series—only the larger members of which were present—from the second series, as is obvious from the curve (Pl. IX, Fig. 5). The millimetre measurements were as follows at and near the point selected:—

100	101	102	103	104	105	106	107	|	108	109	110	111	112	113
10	10	10	9	11	15	21	9	|	8	14	10	13	30	39

Date.	Place.	Series I.				Series II.				Series III.			
		No.	Range.	Average.	Mean.	No.	Range.	Average.	Mean.	No.	Range.	Average.	Mean.
October 18, 24	- Aberdeen, -	4	31-45	38.3	37.5	15	82-94	86.6	88	92	107-130	114.5	118.5
" 22,	- Dornoch, -	1	54	...	...	16	65-96	81.7	80.5	26	100-124	114.6	112
Oct. combined, -		5	31-54	41.4	42.5	31	65-96	84.1	80.5	118	100-130	114.5	115
November 11,	- Dornoch, -	33	45-61	55.6	53	1650	62-98	75.5	80	9	102-112	...	...
" 28,	- Aberdeen, -	...	...	...	...	1	87	...	...	13	113-125	120.2	119
Nov. combined, -		33	45-61	55.6	53	1651	62-98	75.5	80	22	102-125	114.4	113.5
December 12,	- Aberdeen, -	47	49-60	55.5	54.5	24	62-97	77.6	...	2	101-102	...	...
" 18,	- " -	...	...	...	...	22	66-84	73.7	...	4	100-132	111.7	...
" 19,	- " -	...	...	...	...	70	67-97	78.7	...	4	104-111	107.6	...
" 29,	- " -	...	...	...	...	...	...	...	...	39	98-128	111.1	...
" 25,	- Dornoch, -	...	...	...	...	168	72-98	86.6	85	16	103-122	112.1	112.5
" 27,	- " -	3	55-60	57.7	...	36	63-97	76.6	80	54	100-127	107.8	113.5
" 28,	- " -	19	39-60	53.2	49.5	575	62-97	79.5	79.5	128	98-125	109.7	111.5
" 25,	- Burghead, -	...	...	...	...	16	79-95	86.1	87	520	97-138	121.1	117.5
" 28,	- " -	25	50-61	55.8	55.5	436	63-91	75.2	77	27	96-124	116.0	110.
Dec. combined, -		94	39-61	55.8	50.0	1347	62-98	78.9	80.0	794	96-138	117.4	117

The Table giving the particulars of the sprats obtained in the various collections is given on page 178, and a comparison may now be made between the average size indicated for the various groups.

If the difference between the average size of the groups be calculated, it will be found that the amount between the first and second series is as follows in the various months:—23·1mm. for all the December collections combined, 33·2 for April, 42·7 for October, 19·9 for November; the mean for the four being 29·7mm., or about one and three sixteenths of an inch. The difference in some of the cases is considerable, and this is owing in large measure to the very small numbers obtained, and to the fact, still more, that the great majority of the smaller specimens escaped through the meshes of the net. The large difference in the average size in October is due to the fact that the first series was represented by four specimens got in the tow-net and measuring from 31 to 45mm., and one specimen of 54mm., and, on the other hand, to the average of the few specimens in the next series being too high, as already referred to. The low average for November was caused by the opposite, and especially by the average for the first series being exceptionally high. From this circumstance, the fact that only the larger specimens of the first series were taken in the small-meshed net, comparison may also be made between what I have termed the mean, which is based on the intermediate size between the largest and the smallest in a group. This system has also its disadvantages, unless the largest and the smallest fishes present fairly represent the limits of the series, but it tends to diminish the predominance of the larger fishes in obtaining the arithmetical average. On this basis, the respective differences between the averages of the first and second groups are these:—35·0 for April, 38 for October, 27 for November, and 30 for December, the mean of the lot being 32·5mm. The presence of small fishes in the tow-net, as small as 39mm. in December, and 40mm. in April in the shrimp-net, shows that the true average is under that arithmetically calculated.

The differences between the averages of the second and third series are as follows:—March 21·0, April 36·6, May 37·5, October 30·4, November 38·9, and December 38·5, the mean of the differences being 33·8. This amount is rather above the natural difference owing to the fact adverted to, that the larger fishes, many of which no doubt belong to a fourth group, are included in the third group, and thus the average of the latter is somewhat raised. The mean of the combined differences is, calculated on the other basis, 35·2mm., or a little over 1½ inches, and this probably represents the amount of annual growth between one series and another in the sprat.

As already stated, the imperfection of the collections of the first or younger group of fishes does not allow an accurate calculation of the size of that group to be made, but from the sizes obtained in April, December, and September it is certain that the range and the average are under what is calculated from the sizes represented. In order to throw light on the subject, I have made a curve (Pl. X), based on the measurements of the best collections, showing the gradual growth of the sprat in the different generations. From this, it appears, that at one year of age, about the beginning of June, the average size of the sprat is a little over 60mm., and when two year's old, at a corresponding period, about 93mm. There are not sufficient data to show the precise size in the next June, but, as in the end of March and the beginning of April the average size is about 118mm., it is probable that at the beginning of June the average size would be a little over 120mm. This would indicate an approximate growth of 30mm. between the first generation and the second, and 27mm. between the second and the third.

The growth of the sprat is thus slow compared to most of the Gadoids, but it is, of course, a much smaller species. Its growth is not greatly inferior to that of the Norway Pout, the smallest of the Gadoids I have dealt with.

In winter, moreover, the curves and measurements show that the growth is very much slower; most of it appears to take place between April and autumn. In this respect the sprat resembles other fishes.

There is one remarkable circumstance about the sprat, that after the third or fourth generation spawns it dies or disappears. Very few fishes seem to survive to the following year; and this forms a contrast to the conditions obtaining among the flat-fishes and most round fishes, in which many generations survive after maturity is reached and spawn in successive years.

With regard to sexual maturity and the age at which it is attained, a comparison may be made between the collections from the Cromarty Firth on 1st June and that from the Dornoch on the 31st March, or two months earlier—two months, moreover, in which growth is comparatively rapid. The curve of the former on Plate VIII (Fig. 7) shows an apparently homogeneous and symmetrical group, from 73 to 110mm., with an average of 92.9mm. As already stated, the condition of the reproductive organs in this series was only partially examined, but if the smaller resembled those of about 104mm.—and spawning, as we have seen, goes on into July, during which a considerable amount of growth occurs—then the whole group would probably spawn, and these fishes were about two years of age. The great group in the March collection, ranging from 108mm. to 139mm., were obviously all approaching ripeness or fully matured, and would all spawn in the course of the season. It is probable, also, from the condition of the reproductive organs, that the next younger generation, or those two years of age, would spawn also before the close of the season, or at all events the males would, and in that case they would come into line with the series got at Cromarty, and indicate that sexual maturity is reached at two years of age.

The average length and weight of the sprats at one, two, and three years of age, according to this research, are approximately as follows:—

	Mm	Grammes.	Increase.	
			Mm.	Grammes.
One year, - -	63	1.4	...	...
Two years, - -	93	5.0	30	3.6
Three years, -	120	12.5	27	7.5

In the investigation made by Jenkins, based on the examination of the ear-bones, three generations were also determined, but the average sizes do not correspond. His results are as follows, the weights here inserted being derived from my observations on the relation of weight to length, as described on page 145.

	Mm.	Grammes.	Increase	
			Mm.	Grammes.
First year, - -	75	2.5	..	..
Second year, -	110	9.2	35	6.7
Third year, - -	130	16.4	20	7.2

TABLE I.
MEASUREMENTS OF SPRATS IN 2MM. GROUPS.

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TABLE L—*continued.*

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TABLE I.—continued.

[illegible]

TABLE I.—*continued.*

1	2	3	4
1881	1882	1883	1884
1885	1886	1887	1888
1889	1890	1891	1892
1893	1894	1895	1896
1897	1898	1899	1900
1901	1902	1903	1904
1905	1906	1907	1908
1909	1910	1911	1912
1913	1914	1915	1916
1917	1918	1919	1920
1921	1922	1923	1924
1925	1926	1927	1928
1929	1930	1931	1932
1933	1934	1935	1936
1937	1938	1939	1940
1941	1942	1943	1944
1945	1946	1947	1948
1949	1950	1951	1952

6. WITCH (*Pleuronectes cynoglossus*, L.).

There now exists a considerable amount of material to show the growth of this flat-fish in the earlier period of its life, for the first few generations, young forms having been procured in the tow-nets or the fine-meshed net used with the otter-trawl.

The witch spawns rather later than most of the other pleuronectids. On the east coast of Scotland the spawning period was found by me to extend from May to August, the maximum spawning occurring about the end of June.* Cunningham found it spawning in the Clyde towards the end of June,† and Williamson obtained the floating eggs in Lochfyne in each month from April to August inclusive—sparingly in these two months, and most abundantly in June.‡ Holt found ripe specimens on the west coast of Ireland in March, April, and May, and expressed the opinion that it also spawns in June;§ and Herdman and Dawson, with reference to the Irish Sea, describe this fish as spawning from May to July.||

The spawning period may therefore be regarded as extending from April into August, with a maximum towards the end of June.

The egg measures from 1·15 to 1·19mm. and according to Cunningham hatches at temperatures varying from 53° to 68° on the sixth day, and at lower temperatures on the ninth day. Holt found that the eggs fertilised by him on 14th May hatched mostly on the seventh day; some as early as the sixth and others as late as the ninth day, but the temperature of the water was not noted. The surface and bottom temperatures off the Firth of Forth, where the depth is about thirty fathoms, are approximately as follows in the months during which the witch spawns.

	April.	May.	June.	July.	August.
Surface, - -	43·3°	46·5°	51°	54·3°	55°
Bottom, - -	41·6°	44·3°	45°	48·5°	51·5°

The lower temperatures mentioned by Cunningham are not specified, and the eggs of the witch were not among those submitted to temperature-experiments by Dannevig at Dunbar. But in the experiments referred to¶ it was found that the egg of the cod, which is larger than that of the witch, being about 1·39mm., took 15½ days to hatch at a temperature of 42°·8, 12¾ days at 46°·4, 10½ days at 50°, and 9¾ days at 53°·6; while the egg of the flounder, which is smaller than that of the witch, measuring 0·95 to 1·05mm. in diameter, at the same temperatures hatched in 6½, 5½, 4½ and 3¾ days respectively. It may therefore be assumed that if the bulk of the eggs of the witch be spawned in the latter part of June, the majority of the larvæ hatch out about a week later, or, approximately, at the beginning of July. The hatching period, owing to the influence of temperature, will be more contracted than the period of spawning.

* *Eighth Ann. Report Fishery Board for Scotland, Part III.*, p. 263 (1890); *Ninth ibid.* p. 264; *Tenth ibid.*, pp. 234, 242.

† *Trans. Roy. Soc. Edinr.*, vol. xxxii., Pt. I., p. 101 (1887).

‡ *Seventeenth Ann. Rep. Fishery Board for Scotland, Part III.*, p. 99 (1899).

§ *Rep. to Council, Roy. Dublin Soc.* for 1851, p. 258 (1892).

|| "Fishes and Fisheries of the Irish Sea," p. 55. (1902).

¶ *Thirteenth Ann. Rep. Fishery Board for Scotland, Part III.*, p. 147.

The larval witch on escaping from the egg measures, according to Holt,* about 3·99mm., and ten days after hatching, when the yolk was exhausted, a specimen measured 5·57mm. Cunningham found that in forty-eight hours after hatching the length of the larva increased from 3·9 to 5·9mm., a rapid increase. From the very considerable length at which transformation is completed, it is evident that the pelagic stage of this species is comparatively prolonged; one, incompletely transformed, with the left eye on the ridge of the head, and measuring 40mm. in length, was taken by myself on 15th January off Aberdeen.

In the present Report (p. 270) Dr. H. C. Williamson describes the post-larval and early young stages of the witch.

In the accompanying Table I give the particulars concerning 151 post-larval witches caught in tow-nets at various depths in Aberdeen Bay and off it, in the Dornoch Firth, and in the Clyde.

Sci. Trans. Roy. Dubl. Soc. V. (Ser. II.), p. 84 (1893).

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They are to be found in Aberdeen Bay in October and November, and, as above stated, an odd specimen may be procured even in January. The size of those obtained ranged from 12 to 40mm. ($\frac{1}{2}$ – $1\frac{5}{8}$ inches), transformation being completed and bottom-life begun as a rule about the latter size. In the Dornoch Firth a few were also obtained in October and November, from 22 to 38mm. In the Clyde, in the deep water across the mouth of the Firth, in June and July, a number were procured ranging from 6.5 to 37mm., the smaller forms being generally caught towards the surface and the larger forms deeper. On 1st August these measured 14, 15, and 17mm. I am indebted to Dr. Williamson for particulars of these.

In the absence of a complete periodic series of tow-net collections extending over the whole time from the beginning of spawning, it is not possible to tell the age of the specimens given in the Table; but if spawning ceases in August it follows that those got in Aberdeen Bay in October and November must be two months old, and may be more, and that the specimen, incompletely metamorphosed, procured on 15th January, was over four months old. The size at which metamorphosis is completed, and therefore the duration of the pelagic stage in this species, is therefore considerable.

The young forms living on the bottom were also sometimes caught in the small-meshed net, enveloping the cod-end of the otter-trawl, or in the shrimp-trawl. Thus, on 24th October, in sixty fathoms some miles off Aberdeen, nine specimens were taken, five of which measured 42mm., and one each 37, 38, 40, and 43mm. These clearly belonged to the preceding spawning season, and would be a few months old. On 28th December, in thirty fathoms, off Burghead Bay in the Moray Firth, fourteen specimens were secured which measured as follows:—

Mm.	40	41	42	43	44	45	46	47	48	49	63
	2	1	1	3	2	1	1	—	1	1	1

All these also belonged to the previous spawning season; the next largest got in the net was 137mm. (*see below*).

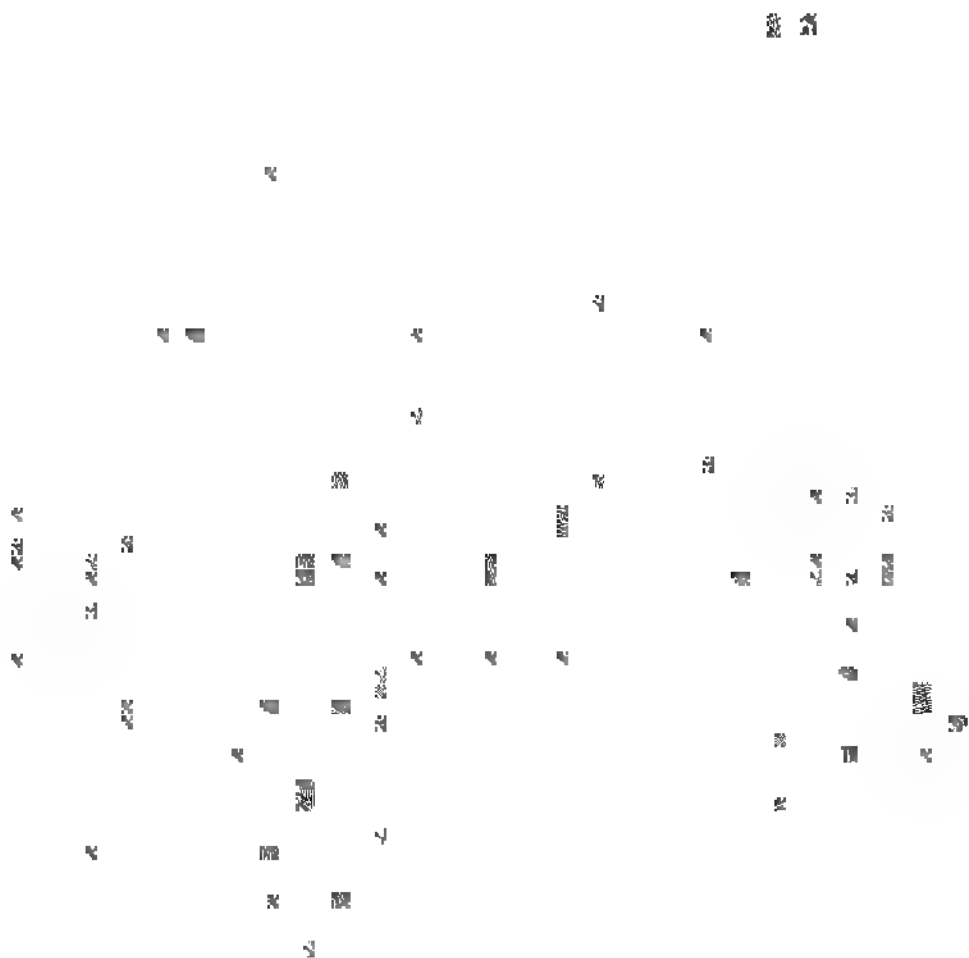
In the same locality, on 14th November, one measuring 56mm. ($2\frac{3}{8}$ inches) was taken, and it belongs to the same category. On 21st January, in fifty fathoms, in the Moray Firth, a specimen of 47mm. was taken; on 23rd January, in the same place, another of 45mm., the tail of which was, however, damaged, and its real length would be several millimetres greater. On 1st April, off Burghead Bay, in thirty-two fathoms, seven small witches were caught of the following sizes:—60, 65, 66, 74, 76, 77, 83mm. ($2\frac{3}{8}$ – $3\frac{1}{4}$ inches), which would be, approximately, from eight to ten months old; the next largest was 144mm.

On the west coast, two were caught in Loch Long, off Ruad Dubh, in thirty-five fathoms, on 20th September, which measured 57 and 58mm. respectively; on 17th September, in Upper Loch Etive, in fifty-two fathoms, six were taken, four of which measured 47mm., one 57 mm., and one 60 mm.; on 21st April, one measuring 90mm. ($3\frac{1}{2}$ inches) was obtained seventeen miles off Corsewall Point. There seems little doubt that all these also belonged to the spawning-season immediately preceding.

Holt, on the coast of Ireland, caught specimens of 42mm. in eighty fathoms on 19th August, which he was of opinion were from eggs spawned early in the season, and were thus from four to six months old; and in July he got one in one hundred and forty-four fathoms, measuring 12.5cm., which he believed to be about one year or more old.*

In some of the hauls a number of specimens were procured belonging to a fairly well-defined older group, and these, with some others, are represented in the accompanying Table.

* *Sci. Trans. Roy. Dublin Soc.* V (Ser. II.) 85



Thus, in the haul of 14th November (I) there were eight specimens between 13 and 16cm. (viz.:—132, 140, 144, 146, 148, 152, 156, 161mm.), and the next size was 242mm. In that of 28th December the group was represented by ten specimens, measuring from 137mm. to 168mm., the next largest being 215mm.; in the haul of 23rd January it was represented by nine specimens, from 138 to 186mm., the next size being 222mm., and in the haul of 1st April by forty-four, from 144 to 191mm., the next largest being 217mm.

A consideration of the first and second series or generations in these cases throws light on the rate of growth of the fish, and the measurements may be grouped as follows, showing the smallest and largest specimens represented in each case, and the mean size: —

FIRST SERIES.						
Date.	No.	Smallest.	Largest.	Range.	Arithmetic Average.	Geometric Mean.
1903. 14th November, -	1	Mm. -	Mm. -	Mm. -	Mm. 56	Mm. -
28th December, -	14	40	62	22	44·7	52·0
1904. 23rd January, -	1	-	-	-	47·0	-
1st April, - -	7	60	83	23	71·6	71·5
SECOND SERIES.						
Date.	No.	Smallest.	Largest.	Range.	Arithmetic Average.	Geometric Mean.
1903. 14th November, -	8	Mm. 132	Mm. 161	Mm. 29	Mm. 147·4	Mm. 146·5
28th December, -	10	137	168	31	150·2	152·5
1904. 23rd January, -	9	138	186	48	167·4	162·0
1st April, - -	44	144	191	47	166·1	167·5

The arithmetic average, it may be explained, is obtained by adding up the sizes of the fishes represented in each group and dividing by the number of fishes; it will deviate from the true average size in one direction or the other if the larger or the smaller fishes of the group predominate in numbers. The geometric mean is the middle figure between the extreme sizes, viz.:—the largest fish and the smallest; its accuracy depends upon the limits of the group being truly indicated.

Considering first the difference in size between the first series of witches and the second series, which are one year older, it is evident that the size of the single specimens of the first series obtained on 14th November and 23rd January respectively, are not representative, the former (56mm.) being too large and the latter (47mm.) too small. This is shown by the townet collections in October and November, as represented in Table A. and Plate XI, in which specimens measuring

from 12mm. to 40mm. were secured. The differences between the two series on 28th December and on 1st April are these :—

	Smallest.	Largest.	Arithmetic Average.	Geometric Mean.
	Mm.	Mm.	Mm.	Mm.
28th December, -	97	104	105·5	100·5
1st April, - -	84	108	94·5	96·0

If the mean of the average sizes be taken for the two hauls, the difference between the first series and the second series is, for the arithmetic average, 100·0mm., and for the geometric, 98·3mm—and this might be taken as approximately representing the increase in growth in length in the witch at this stage in one year, *i.e.*, about 3 $\frac{7}{8}$ inches. It will be seen, however, as is the general rule, that the average difference in length is greater at the earlier date than at the later ; in other words, that the younger fishes increase in length more rapidly than those one year older. The annual increment is therefore better represented on 1st April than on 28th December ; and since 1st April is two or three months anterior to the height of the hatching season, and the more rapid growth in length of the smaller fishes continues, the true difference in length between witches which are one year old and those which are two years old is probably under 90mm. (3 $\frac{1}{2}$ inches). The average length of a one-year-old witch appears to be about 3 $\frac{1}{2}$ inches, and that of a two-year-old somewhat under 7 inches.

The above Tables also furnish information as to the growth of the first and the second series between the dates of the collections. Thus, in the ninety-five days between 28th December and 1st April the increments of the first series of witches was as follows :—

Smallest.	Largest.	Arithmetic Average.	Geometric Mean.
Mm. 20	Mm. 21	Mm. 26·9	Mm. 19·5

In the period mentioned, therefore, the young witches grew a little over 20mm. longer—about $\frac{7}{8}$ of an inch. The second series of older fishes grew less rapidly. Comparison of the sizes at the various dates shows the following increases :—

	No. of Days.	Increase.			
		Of Smallest Fish.	Of Largest Fish.	Average.	Mean.
14th November to 28th December,	44	Mm. 5	Mm. 7	Mm. 2·8	Mm. 6·0
28th December to 23rd January, -	26	1	18	17·2	9·5
23rd January to 1st April, -	69	6	5	—1·3	5·5
28th December to 1st April, -	95	7	23	15·9	15·0
14th November to 1st April, -	139	12	30	18·7	21·0

The increase in length in the ninety-five days from 28th December to 1st April amounted to about 15mm. ($\frac{5}{8}$ inch); on the 139 days from 14th November to 1st April, to about 20mm. ($\frac{3}{4}$ inch). It will be noticed, as pointed out in previous reports, that the larger fishes of an early series grow more rapidly than the smallest, i.e., the variation in the sizes of the individual fishes of the group—due primarily to a difference in the time of hatching, early or late—becomes more pronounced, which is one of the causes of the coalescence of the older generations or groups. It will also be observed that, so far as these data go, growth was more rapid in December and January than in spring. This might be expected from the higher temperature of the bottom water in the depths where the witches lived during the former months, growth being closely related to temperature. Unfortunately, no observations have yet been made with sufficient frequency to enable the temperatures at these depths in the northern waters to be approximately stated for the various months of the year. Off the Firth of Forth, in thirty fathoms, according to the *Garland's* observations, the mean bottom-temperature in the months referred to were—November, 49° F.; December, 49·2°; January, 41·7°; February, 41·3°; March, 40·1°; April 43·3°.

With regard to the sizes and growth of the witches of older series, above two years, there is more difficulty, owing to the coalescence of the groups, and the different rate of growth of the males and females after sexal maturity is attained; and there are not yet sufficient observations on the older males and females to make the matter clear. In most of the collections, as may be observed from the table, there is a general absence of specimens between the second and third groups, and it is not certain whether this gap is natural, i.e., that it is caused by there being really no

intermediate sizes, the growth of the largest of the second series not having brought that series up to the third—or whether it is owing to the imperfect collections. A comparison of the measurements at the different dates shows that the latter factor at least partly accounts for it, inasmuch as smaller specimens of the third series were obtained in January and April than in November as shown:—

Cm.	15	15·5	16	16·5	17	17·5	18	18·5	19	19·5	20	20·5	21	21·5	22	22·5	23	23·5	24
11th Nov.,	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
28th Dec.,	2	1	1	1	-	-	-	-	-	-	-	-	-	1	-	2	-	-	2
23rd Jan.,	1	1	-	-	3	1	1	1	-	-	-	-	-	-	1	-	1	2	2
1st April,	8	11	7	8	-	2	-	1	1	-	-	-	-	1	1	-	1	2	3

In the curves of measurements there is a marked drop indicating a division between the third and the fourth series, but it does not agree in the different cases, and is based upon not very many mixed measurements of males and females. The lowest point is at 30-31cm. in November, 27cm. in January, 30-31cm. in December, and 29cm. in April. Study of the curves of the other series of measurements given in the Table shows that the fixing of the division between the third and fourth groups must be deferred. If, however, as reasoned above, a two-year-old witch measures on the average about 7 inches, and the rate of growth is slightly reduced, the average length when three years old will probably be about 10 inches, or 25cm., with a range for the group of approximately from 8½ to 11½ inches.

The average size and the range of size at which maturity is first reached in the males and females are not yet sufficiently elucidated. I found females ripe at 14 inches, spent at 13 inches, and nearly ripe at 12½ inches; and males ripe at 15 inches, nearly ripe at 11½ inches.* On the west coast of Ireland the smallest ripe female found by Holt was twelve inches, and the smallest approaching ripeness was also 12 inches; the smallest ripe male was 10½ inches, and the smallest approaching ripeness 10 inches.†

From these facts it appears that the female witch does not spawn before the fourth year; some males may possibly become mature in their third year. It is noteworthy that in this species, under certain sizes the males are much more numerous than the females. In 2348 specimens under 16 inches, and mostly from 10 to 13 inches, the greater part of which were examined by Mr. F. G. Pearcey on board the *Garland*, 915 were females and 1833 were males, the males at these sizes being thus rather more than twice as numerous as the females. In 104 examined by myself there were sixty-seven males and thirty-seven females. Among large witches, on the other hand, from 13 or 14 inches upwards the proportions of the sexes are reversed. Of 422 examined, 306 were females (34-50cm.) and 116 males.

7. THE NORWAY POUT (*Gadus Esmarkii*).

Since describing the observations made on the growth of this species in the Nineteenth Annual Report‡ collections have been obtained and measurements made on several occasions. Most of the fish were caught in the Moray Firth, or off Aberdeen, but in two instances collections were secured in the deep water off the Shetlands. The first haul was for forty-five minutes on 19th May, 1901, in sixty-five fathoms, about fifty-three miles S.E. by S. ¼ S. from the south point of Fetlar Island, Shetland; the bottom temperature was 42·5° C., and the surface 46·6° C. The number of Norway Pouts caught was 285, almost all belonging to one

* *Eighth Ann. Rep. Fishery Board for Scotland* Part III., p. 161) 1890); *Tenth ibid.*, p. 239.

† *Report of Council for 1891, Roy. Dublin Soc.*, p. 272.

‡ Part III., p. 155 (1901).

series, which extended from 85mm. to 129mm., the range being thus 44mm. The arithmetic average size for the 279 in the series was 106·2mm., the mean was 107mm., and the maximum ordinate 10·5cm. (Pl. XII). The remaining six fishes, measuring from 137 to 149mm., represented part of the second series.

The next collection was obtained on 11th December, 1901, from the grounds seventy-five miles south-east of Sumburgh Head, Shetland, in seventy-five fathoms of water. The number of specimens secured in the small-meshed net was 704. Most of them belonged to one series, although three were represented. The first was not well represented, and was not cut off so sharply from the next series of larger fishes as in the hauls in September and October of the preceding year.*

The measurements, in 1cm. groupings, are given in the Table appended ; and the 2mm. grouping is as follows at the point of division :—

115-6	117-8	119-20	121-2	123-4	125-6	127-8	129-30	131-2
10	11	7	5	1	4	14	21	25

This series extends from 97mm. to 122mm., a range of 25mm. ; the smaller forms are no doubt absent. The arithmetic average size of the eighty-five fishes contained in it was 111·5mm., and the mean was 109·5mm. The maximum range in this series in the collections made in October 1900, which included 1553 fishes, was 50mm., and if this be applied in the present case it would make the size of the smallest belonging to it about 72mm., and the mean size on this basis would be about 97mm.

The next older group begins at 124mm., and apparently extends to 180mm. or 182mm., but it is possible it terminates at about 164mm. The two-millimetre grouping from 157mm. to the end is as follows :—

157-8	159-60	161-2	163-4	165-6	167-8	169-70	171-2	173-4	175-6	177-8
14	8	6	4	7	12	6	4	4	5	5
170-80	181-2	183-4	185-6	187-8	189-90	191-2	193-4	195-6	197-8	
3	1	-	1	3	-	1	-	2	1	

Taking the series as ending at 182mm., the range of the 611 fishes composing it amounts to 58mm. ; the arithmetic average size is 142·3mm. and the mean 153mm. There were other eight fishes, the largest being 197mm., which evidently belong to a third series. The arithmetic average size is 190·9mm.

For comparison with the preceding collections taken in the same neighbourhood I give here the main features in tabular form, the averages being the actual arithmetical average.

Date.	1st Series.		2nd Series.		3rd Series.	
	Range.	Average.	Range.	Average.	Range.	Average.
1900. 31 August	mm. -	mm. -	mm. 110-162	mm. 140·2	mm. 163-213	mm. 176·8
4 September	51-92	78·7	117-155	136·0	157-200	168·9
16-19 Octr.	66-116	87·7	119-172	143·6	177-197	182·5
1901. 19 May	85-129	106·2	-	-	-	-
11 December	97-122	111·5	124-182	142·3	185-197	190·9

* *Loc. cit.*, plate ix.

If, however, the series ends at 164mm., then the average size of the second group would be 139·9mm., the mean size 144, and the range 40mm.; the third group would have a range of 32mm., an average size of 174·1, and a mean of 181mm.

The differences between the average size of the various groups as shown above are as follows:—

1st to 2nd.	2nd to 3rd.
...	36·6
57·3	32·9
55·9	38·9
20·8 [45·3]	48·6

In the December haul the first and third series were very imperfectly represented (see Pl. XII.), and the averages given do not correctly show the proper sizes. The figures in brackets indicate the difference of the corrected means.

Collections of the Norway Pout were also made at various times a few miles off Aberdeen in the deep water known as the Dog Hole, the depth varying from about fifty to about seventy fathoms.

The first was on 28th June, in sixty-five fathoms, eleven miles off; the bottom temperature was 48·2° F., and the surface temperature 52·5° F. The number of specimens procured was 141. One of those was a very small one, measuring 27mm., no doubt spawned some months earlier. The next series comprised 131, ranging in size from 125mm. to 172mm., the range being 47mm.; the arithmetical average size was 150·2mm., the mean 148·5mm., and the maximum ordinate 14·5cm. There were six in a third group, ranging from 178 to 194mm., with an average size of 187·2mm., the mean being 186mm. Other three probably formed a fourth series, the sizes being 210, 215, and 222mm., and the average 212·3 mm.

In the next collection, on 30th July, in sixty-two fathoms, the bottom temperature being 57° F., and the surface temperature 58·6° F., 350 specimens were taken, all belonging, apparently, to the same series. The range of sizes was from 120mm. to 184mm., or an extent of 64mm.; the arithmetical average was 155·1mm., the mean 152mm., and the maximum ordinate 15·5mm.

The third lot was got on 21st August, in fifty-eight fathoms, the surface temperature being 55·9° F., and they numbered 218 specimens. Two, possibly three, series, were present. The first comprised three fishes, measuring 67, 81, and 83mm. The second included 214, from 130mm. to 189mm., the range being thus 59mm.; the average size was 158·8mm., the mean 159·5, and the maximum ordinate 16cm.

On 3rd September, the fourth collection was made in fifty-eight fathoms in the same locality, the bottom temperature being 53° F., and the surface temperature 53·2°. Most of the fishes in the small-meshed net escaped, owing to a hole in it; the number of Norway Pouts obtained was fifteen, ranging from 132 to 168mm., the average size being 156·9mm., the mean 150mm., and the maximum ordinate 16cm.

A few days later, on 10th September, eight specimens were taken in Aberdeen Bay, measuring 76, 77, 83, 85, 87, 91, 93, 94mm. respectively. The average size was 85·7mm., the mean 85, and the maximum ordinate 9cm.

The next collection at the Dog Hole was on 16th December, in fifty-seven fathoms, the bottom temperature being 46·2° F. The number of specimens taken was fifty-four, belonging to two series. The first included

seventeen fishes, measuring from 114mm. to 132mm.; the average size was 124·7mm., the mean 123mm., and the maximum ordinate between 12 and 12·5cm. The second series comprised thirty-seven fishes, ranging from 142mm. to 184mm.; the arithmetic average size was 160·8, the mean 163mm., and the maximum ordinate 15·5cm.

The particulars in regard to the specimens taken off Aberdeen may be summed up in the following Table, which also includes a number caught in the same locality by the *Garland* in October and November of the previous year:—

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The hauls on 9th November 1900, and 10th September 1901, were taken in Aberdeen Bay in about ten fathoms; all the others in 1900 in deeper water, from thirty-three to sixty fathoms up to ten miles from shore.

Beginning with the younger fishes, the one taken at the end of June, measuring 27mm. ($1\frac{1}{8}$ inch), was doubtless about two or three months old, and derived from the spawning in the previous spring. This series was not represented in the July collection, but in August the three measuring 67, 81, and 83mm. were no doubt large members of this group; the average size at this period is probably under what is given in the Table. On 10th September, in Aberdeen Bay, the eight specimens of this series taken had an average length of 85·7mm.; and three months later, on 16th December, the average size of seventeen was 124·7mm. This would indicate an increment of 39mm. in the period named, and 47·7mm. from 21st August, 117 days earlier, or 4·08mm. per ten days, which is too large.

In the Firth of Clyde a few collections were also obtained, but the numbers were small. On 15th July, 1899, one was taken in a few fathoms of water in Machray Bay, Arran; it measured 85mm. On 4th October, 1901, thirty-six were caught in the shrimp-net of the *Garland* between Rhoad Point and Ailsa Craig. They ranged in size from 63mm. to 97mm.; the arithmetical average size was 83·5mm., and the mean 80mm., and they no doubt belonged to the same year's spawning.

In the Moray Firth the Norway Pout is fairly common in the deeper water, and some collections were in sufficient numbers to enable curves of their measurements to be drawn. On 4th July, 1901, a small collection, consisting of sixteen specimens, was procured in fifty fathoms a few

miles from Kinnaird Head. They appeared to belong to two groups, the first consisting of eleven, ranging in length from 125mm. to 172mm., with an average of 154·3mm., and the second of five specimens from 183 to 202mm., the average being 190·2mm.

On 14th November, 1903, 432 were taken in thirty fathoms off Burghead Bay, belonging to two series. The first comprised 369 specimens, varying in length from 75 to 137mm., the average size being 108·0mm., the mean 106mm., and the maximum ordinate 10·5cm. The second series, of sixty-three fishes, extended from 141mm. to 173mm., the average size being 150·5mm., the mean 157mm., and the maximum ordinate 15·5cm.

In the same locality another collection was made, in thirty fathoms, on 28th December, 1903, and 307 specimens procured, all belonging to the same series. The sizes ranged from 88mm. to 124mm., the average being 103·4mm., the mean 106mm., and the maximum ordinate 10·5cm.

A fourth collection in this locality was procured on 1st April, 1904, and apparently only one series was represented. It comprised 347 specimens, ranging in size from 93mm. to 139mm., the average being 110·2mm. or $4\frac{3}{8}$ inches, and the mean 116mm.

On 23rd January 1904, 250 specimens were procured in fifty fathoms, off Kinnaird Head, three series being represented. The first consisted of 205, ranging in size from 96mm. to 136mm.; the average was 115·3, the mean 116mm., and the maximum ordinate 12·5cm. The next group was composed of forty-four, from 145mm. to 181mm.; the average being 158·6, the mean 163mm., and the maximum ordinate 15·5cm. There was a large one measuring 203mm.

The particulars are given in the accompanying Table:—

Date and Place.	SERIES I.			SERIES II.			SERIES III.		
	No.	Range.	Average.	No.	Range.	Average.	No.	Range.	Average.
		Mm.	Mm.		Mm.	Mm.		Mm.	Mm.
Off Burghead,	...	...	...	...	...	...	...	...	...
14th Nov. 1903,	355	75-126	107·0	77	127-173	147·1	...	...	...
28th Dec. ,,	307	88-124	103·4	...	...	...	...	...	...
1st April 1904,	347	93-139	110·2	...	...	...	...	...	...
Off Kinnaird Head,	...	...	...	...	...	...	...	...	...
4th July 1901,	11	125-172	154·3	5	183-202	190·2	...	...	...
23rd Jan. ,,	205	96-136	115·3	44	145-181	158·6	1	203	...

In these collections it will be observed that as a rule the second series is poorly represented. The apparent annual increment of length amounting in the three cases in which comparison can be made to 40·1, 35·7, and 43·3mm., the mean of the three being 39·7mm., or $1\frac{1}{2}$ inches.

The information that may be derived from the Table as to the rate of growth from one date to the other is not very great, the successive averages irrespective of place being 107·0, 103·4, 115·3, 110·2 and 154·3. The latter is based upon only eleven specimens, and is too large, larger, indeed, than the average in November, 147·1, which deals with the measurement of seventy-seven fishes.

Information as to the size at which the Norway Pout becomes mature is scanty, the only observations, as far as I know, being those by Holt,* who found two ripe females, each $4\frac{1}{2}$ inches in length on the west coast of Ireland early in April.

I examined the condition of the reproductive organs in many of the specimens procured by me.

Seven females from the collection obtained off Burghead on 14th November, varying in size from 151 to 171mm. ($6-6\frac{3}{4}$ inches), had small ovaries, the largest eggs ranging in diameter from .189 to .231mm., Others on 28th December, from 95 to 118mm., had the ovaries only "slightly developed," but the size of the eggs was not determined. On 23rd January some of those caught in fifty fathoms off Kinnaird Head were examined, and both the weight of the ovary and the diameter of the largest eggs had considerably increased. The following Table exhibits the particulars, the dimensions being in millimetres, and the weight in grammes. The first six are from the November collection, and the others from that in January.

Length.	Gross Weight.	Weight of Ovary.	Diameter of Largest Eggs.
151	27.9	..	.21
152	28.2	.17	.21
157	30.9	.12	.23
158	31.2	.16	.189
164	32.6	..	.21
171	38.4	..	.21
153	24.7	.5	.44
155	26.5	.7	.46
155	28.6	1.3	.57
155	28.4	1.1	..
155	26.7	.8	..
158	31.0	1.8	..
161	31.7	1.2	.57-.63
180	41.0	1.3	.50
202	67.1	3.4	.59-.63

Those examined from the collection made off Burghead on 1st April were all "quite immature," their sizes ranging from 93 to 139mm. ($3\frac{1}{2}-5\frac{1}{2}$ inches) so that this circumstance together with the facts in the above Table appear to show that spawning occurs probably in February and March.

A Table giving the measurements in twenty collections, arranged in half-centimetres, is appended.

* *Roy. Dubl. Soc. Report of Council for 1891.* App., p. 291.

- I. Aberdeen Bay, 12th October, 1900.
- II. " 23rd October, 1900.
- III. " 7th November, 1900.
- IV. Dog Hole, off Aberdeen, 28th June, 1901.
- V. " " 30th July, 1901.
- VI. " " 21st August, 1901.
- VII. " " 8rd September, 1901.
- VIII. " " 18th December, 1901.
- IX. Deep Water, off Shetlands, 19th May, 1901.
- X. " " 31st August, 1900.
- XI. " " 4th September, 1900.

- XII. Deep Water, off Shetlands, 16th October, 1900.
- XIII. " " 19th October, 1900.
- XIV. " " 11th December, 1901.
- XV. Deep Water, Moray Firth, off Kinnauld, 23rd January, 1904.
- XVI. Moray Firth, off Burghhead, 1st April, 1904.
- XVII. " off Kinnauld, 4th July, 1901.
- XVIII. " off Burghhead, 14th November, 1903.
- XIX. " " 23th December, 1903.
- XX. Firth of Clyde, between Rhoad Point and Ailsa Craig, 4th October, 1901.

8. THE SHARP-TAILED LUMPENUS (*Lumpenus lampetriformis*.)

Fairly large numbers of this fish are taken in the small meshed-net around the otter-trawl, more especially in the deeper parts of the Moray Firth, as off Kinnaird Head, and at the mouth of the Firth of Forth, and some of the collections have been measured. The best of these was one got at Station V. in the Firth of Forth, on 10th May, 1901, which comprised 255 specimens. They ranged in length from 127mm. to 345mm. (5 - 13½ inches). The measurements, grouped in half centimetres, are appended, and the curve is given in Plate XI. It is apparent from these that at least three series, and possibly five, are represented in the collection. What appears to be a first series is indicated by two specimens, measuring 127mm. and 128mm., the next size being 138mm. On the 16th May, on the same ground, a still smaller one was captured, viz., at 123mm., the next measuring 172mm. In a haul on 31st August, off Sumburgh Head, in sixty-five fathoms, the smallest I have obtained was taken, viz., 84mm. ($3\frac{5}{8}$ inches), the next largest in the small collection being 154mm. I am inclined to think that the specimens in the Forth collection referred to were the larger members of an early series, the smaller individuals probably escaping through the meshes of the net; the specimen at 138mm. might also belong to this series.

The second group begins at 138 or 146mm., its division from the third series being fairly well defined at 190mm. The range is thus 52mm., the average size of the thirty-three specimens, 167·8mm. ($6\frac{5}{8}$ inches), and the mean, with the first-named limit, 164mm., and with the series beginning at 146mm., 168mm.

The next group begins at 197mm., and it appears to terminate at 263mm., a range of 66mm. In the curve based on the half-centimetre grouping of the measurements, there is a depression at 23cm.; it does not seem, however, to represent a division between series, but only irregular representation. The number of fishes composing the second series was 127, the arithmetical average size was 235·2mm., and the mean 230mm.

The next series begins at 264mm., and extends to 312mm., a range of 48mm. It comprised seventy-eight fishes, whose average length was 288·9mm., the mean size being 288mm.

The other fifteen fishes in the collection probably belong to an older group. They measure from 315mm. to 345mm., the average size being 325·7mm., and the mean size 330mm.

The averages and limits above given are based on the supposition that five series are represented; but on the assumption that the smaller fishes belong to the same series as the second group, then the extent of the latter would be from 127mm. to 190mm., a range of 63mm., and the average size of the thirty-five fish would be a little less, viz., 165·4mm., the mean being 158·5. If the fifteen larger fishes be included with the preceding series the range would be extended from 264 to 345mm., a difference of 81mm.—obviously too great—and the average size would become 294·9mm., the mean being 304·5mm. Looking at the curve there seems little doubt of the presence in the collection of members of a fourth series, and scarcely less of the presence of the early one.

The amount of annual growth between the series as determined above are as follows:—

	1st to 2nd.	2nd to 3rd.	3rd to 4th.	4th to 5th.
Mm.	- 40·3	67·4	53·7	36·8
Inches,	- $1\frac{5}{8}$	$2\frac{1}{8}$	$2\frac{1}{8}$	$1\frac{7}{8}$

If the two smallest fishes be included in the second group, the difference between the latter and the next older one is 69·8mm.

Some other collections of *Lumpenus* were measured, the largest being one procured off Burghead in thirty-two fathoms on 1st April, and which comprised 365 specimens. These, after being preserved in formaline, were measured by the Laboratory attendant, and the measurements are included in the Table appended. On preparing a curve, however, it is apparent that either the series was irregularly represented, or the measurements faulty, since the divisions between the groups are not marked. Four series, however, at least, seem to be indicated.

With regard to the age of these groups, it is necessary first of all to decide as to the period of spawning, about which little is known. In specimens taken off the Shetlands on 31st August and 4th September, the females, ranging in size from 234mm. to 286mm., had large ovaries, with large eggs from 1·1mm. to 1·44mm. in diameter, the ovaries themselves measuring from 25mm. to 35mm. long.* These specimens were evidently on the eve of spawning.

In a collection procured in the deep water off Kinnaird Head, Moray Firth, on 23rd January, the sizes ranging from 153 mm. to 284 mm., the ovaries were small and lax, and the tissue contained a great number of small dark-brown bodies scattered throughout them, apparently eggs or blood in the process of disintegration and absorption; they appeared to be spent. The same condition was noted in the ovaries of the specimens taken off Burghead on 1st April. On the other hand, in a few specimens procured in the Firth of Forth on 16th August, measuring from 236 mm. to 283 mm., the eggs were well developed, the largest ranging in diameter from 1·1 mm. to 1·4 mm.; the yolk spheres were large and small oil-globules were present.

From these observations it may be concluded that *Lumpenus* spawns in the late part of the autumn or the early part of winter, and it is probable that the eggs—which appear to be demersal—do not hatch until early in spring, which may therefore be taken as the period from which to date the rate of growth.

Looking to the rate of growth between the series as shown above, it is probable that the smaller specimens in May, measuring 123, 127, and 128 mm., were a little over one year of age, the specimen obtained off the Shetlands at the end of August, 84 mm. in length, being probably six or seven months old. The average size of *Lumpenus* when one year old is obviously less than these sizes, the smaller forms having escaped capture.

The information as to the size at which maturity is reached is very scanty, the number of specimens approaching ripeness which were examined having been small. In August the smallest in that condition were 236, 239, 241mm., and they evidently belonged to the same group as the third (197-263mm.) represented in the curve for the May measurements. The probability therefore is that *Lumpenus* spawn when three years of age. It may be noted that many of the largest specimens procured are males. This sex therefore does not, as with the flat-fish, grow at a slower rate after maturity than the females. A Table of measurement of some of the collections is appended.

* *Nineteenth Ann. Report Fishery Board for Scotland, Part III., p. 287.*

Cm.	I.	II.	III.	IV.	V.	VI.	VII.	Cm.	I.	II.	III.	IV.	V.	VI.	VII.
8	...	...	...	...	1	...	...	23	4	...	...	...	1	5	19
.5	...	...	...	...	...	...	...	.5	16	1	...	2	...	8	17
9	...	...	...	...	...	...	...	24	11	...	1	1	...	4	30
.5	...	...	...	...	...	...	...	.5	18	2	1	...	...	2	19
10	...	...	...	...	...	...	...	25	13	1	1	...	...	...	20
.5	...	...	...	...	...	...	...	.5	14	...	2	...	1	1	23
11	...	...	...	...	...	...	...	26	4	...	2	...	...	...	11
.5	...	...	...	...	...	...	...	.5	4	...	1	...	1	...	17
12	...	1	...	...	...	...	...	27	9	...	1	1	2	...	10
.5	2	...	...	...	...	...	...	.5	8	...	...	...	1	1	10
13	...	...	...	...	...	...	...	28	8	...	...	1	1	1	15
.5	1	...	...	...	...	...	...	.5	10	...	1	1	1	...	12
14	...	...	...	...	...	...	...	29	8	...	1	...	...	...	5
.5	1	...	...	...	...	...	...	.5	10	...	...	...	...	...	2
15	2	...	...	...	1	1	...	30	9	...	...	...	1	...	4
.5	5	...	...	...	...	...	2	.5	10	...	...	...	...	...	1
16	4	...	...	...	...	1	4	31	1	...	1	...	...	...	...
.5	8	...	...	...	...	1	3	.5	4	...	...	...	...	...	...
17	2	1	...	...	...	2	9	32	2	...	2	...	...	...	...
.5	4	1	...	...	...	1	4	.5	6	...	...	...	...	...	...
18	2	...	...	...	...	2	10	33	2	...	...	...	1	...	...
.5	3	...	...	...	...	1	11	.5	...	...	...	...	...	...	...
19	1	1	1	...	...	3	8	34	...	...	1	...	...	...	...
.5	2	1	1	...	...	3	7	.5	1	...	...	...	...	...	...
20	2	1	...	...	...	2	13	35	...	...	...	...	...	...	...
.5	9	3	...	1	...	4	7	.5	...	...	...	...	...	...	...
21	9	...	...	...	...	6	18	36	...	...	...	...	...	...	...
.5	6	1	...	...	...	7	14	.5	...	...	...	...	...	...	...
22	10	...	...	...	...	4	17	37	...	...	...	...	...	...	...
.5	10	2	1	...	...	5	23	.5	...	...	...	...	...	...	...

I. Firth of Forth, 10th May, 1901.

II. " " 16th " "

III. " " 23rd, 24th July, 1901.

IV. " " 16th August, 1901.

V. Off Shetlands, 31st August, 1900.

VI. Moray Firth, off Kinnaird Head, 23rd January.

VII. Moray Firth, off Burghead, 1st April.

TABLE A.—SHOWING RLATION BETWEEN LENGTH AND WEIGHT.
PLAICE.

Length.		Weight in Grammes.			Average Weight in Ounces.	No. of Fish.
In Cm.	In Inches.	Average.	Smoothed Average.	Range.		
4.2	1 $\frac{1}{8}$	0.64	...	...	...	1
4.5	1 $\frac{3}{8}$	.79	.77	.71- .85	...	3
4.7	1 $\frac{5}{8}$	.89	.92	.76- .98	...	4
5.0	2	1.09	1.17	.85- 1.48	$\frac{1}{4}$	19
.5	...	1.53	1.51	1.31- 1.77	...	21
6	2 $\frac{1}{8}$	1.92	1.96	1.51- 2.41	...	29
.5	...	2.44	2.50	1.77- 2.83	...	19
7	...	3.15	3.12	2.9 - 3.6	...	7
7.5	...	3.77	3.90	3.3 - 4.17	...	9
8	3 $\frac{1}{8}$	4.77	4.78	3.87- 5.3	...	17
.5	...	5.8	5.72	4.53- 6.34	...	38
9	3 $\frac{3}{8}$	6.58	6.82	5.2 - 7.4	...	35
.5	...	8.09	8.11	6.6 - 8.9	...	34
10	3 $\frac{5}{8}$	9.68	9.62	7.99- 10.9	$\frac{1}{2}$	34
.5	...	11.08	11.20	9.86- 12.8	...	20
11	4 $\frac{1}{8}$	12.84	12.93	11.8 - 14	...	16
.5	...	14.86	14.80	13.0 - 16.8	...	15
12	4 $\frac{3}{8}$	16.69	17.35	15.6 - 18.7	...	9
.5	4 $\frac{5}{8}$	20.49	19.90	17.7 - 24.5	...	11
13	5 $\frac{1}{8}$	22.53	22.41	19.7 - 25.1	...	11
.5	...	24.2	25.46	22.2 - 27.0	...	5
14	5 $\frac{1}{2}$	29.64	27.67	28.3 - 30.9	...	2
.5	...	29.17	31.10	27.4 - 30.2	...	4
15	5 $\frac{3}{8}$	34.5	34.06	32 - 40.1	1.2	6
.5	...	38.5	37.90	35.4 - 40.1	...	3
16	6 $\frac{1}{8}$	40.7	41.03	37.2 - 44.4	1.4	6
.5	...	43.9	44.83	41.1 - 45	...	6
17	6 $\frac{3}{8}$	...	49.55	...	...	...
.5	...	54.9	53.78	47.4 - 58	...	5
18	7 $\frac{1}{8}$	54.6	57.79	...	1.9	1
.5	...	65.0	62.2	...	...	1
19	7 $\frac{3}{8}$	...	67.63	...	...	...
.5	...	69.0	71.54	...	...	1
20	7 $\frac{5}{8}$	78.0	77.10	...	2.7	1
.5	...	84.3	86.1	78 - 92	...	5
21	8 $\frac{1}{8}$	...	95.2	...	...	...
.5	...	104.0	104.6	99 - 107	...	3
22	8 $\frac{3}{8}$	114.7	112.8	113 - 120	...	4
.5	...	119.7	119.9	115 - 127	...	4
23	9 $\frac{1}{8}$	125.2	125.7	115 - 142	...	10
.5	...	132.3	133.0	122 - 139	...	9
24	9 $\frac{3}{8}$	141.6	140.6	127 - 154	...	17

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PLAICE—continued.

Length.		Weight in Grammes.			Average Weight in Ounces.	No. of Fish.
In Cm.	In Inches.	Average.	Smoothed Average.	Range.		
70 ^{.5}	27 ³ / ₈	3908	...	...	...	1
70 ^{.5}	...	...	...	...	...	...
71 ^{.5}	28 ¹ / ₈	4481	...	...	158.2	1
72 ^{.5}	28 ¹ / ₈	...	...	...	...	...
73 ^{.5}	28 ¹ / ₈	...	...	...	...	...
73 ^{.5}	...	...	...	...	...	...
74 ^{.5}	29 ¹ / ₈	...	...	...	...	...
75 ^{.5}	29 ¹ / ₈	...	...	...	...	...
...

LEMON.

6 ^{.5}	2 ³ / ₈	...	...	...	...	...
7 ^{.5}	3 ¹ / ₈	...	...	...	...	...
8 ^{.5}	3 ¹ / ₈	3.35	...	...	...	1
8 ^{.5}	...	...	...	...	...	...
9 ^{.5}	3 ¹ / ₈	...	...	...	...	...
10 ^{.5}	3 ¹ / ₈	...	...	...	...	...
11 ^{.5}	4 ¹ / ₈	...	...	...	...	...
11 ^{.5}	...	14.77	...	...	...	1
12 ^{.5}	4 ¹ / ₈	18.9	...	17.35- 20.5	.66	2
13 ^{.5}	5 ¹ / ₈	20.0	21.3	18.8 - 20.97	...	3
14 ^{.5}	...	23.8	23.0	23 - 24.7	...	6
14 ^{.5}	...	26.0	26.1	22.6 - 29	...	8
15 ^{.5}	...	...	28.5	...	...	...
15 ^{.5}	7 ¹ / ₈	31.15	32.3	26. - 35.5	1.1	4
16 ^{.5}	...	36.1	36.1	34.5 - 37.9	...	6
16 ^{.5}	6 ¹ / ₈	41.2	40.5	38.5 - 44.	...	2
17 ^{.5}	...	44.9	44.9	40.2 - 51.6	...	9
17 ^{.5}	7 ¹ / ₈	48.6	48.3	44.3 - 53.1	...	6
18 ^{.5}	...	51.7	51.8	47.5 - 57.7	...	4
18 ^{.5}	7 ¹ / ₈	...	55.0	...	...	...
19 ^{.5}	...	58.4	61.4	54.3 - 62.4	...	2
19 ^{.5}	8 ¹ / ₈	67.8	68.9	...	...	1

LEMON—continued.

Length.		Weight in Grammes.			Average Weight in Ounces.	No. of Fish.
In Cm.	In Inches.	Average.	Smoothed Average.	Range.		
20	7 ⁵ / ₈	91·0	79·4	84·9 - 99·1	3·2	4
20	7 ⁵ / ₈	99·2	89·3	...	...	1
21	8 ¹ / ₄	105·0	98·0	102 - 106·8	...	3
22	8 ¹ / ₂	...	...	...	...	...
23	9 ¹ / ₈	...	...	...	...	...
23	9 ¹ / ₈	157	...	...	...	1
24	9 ¹ / ₂	...	...	...	...	...
25	10 ¹ / ₈	...	...	...	...	...
26	10 ¹ / ₂	170	...	...	...	1
26	10 ¹ / ₂	214	...	...	...	1
27	11	228·8	...	...	...	1
28	11	...	...	...	...	...
29	11 ¹ / ₂	262	...	241- 283	...	2
29	11 ¹ / ₂	340	...	326- 354	...	2
30	12 ¹ / ₈	...	...	...	...	...
31	12 ¹ / ₂	346	363	319- 361	12·2	3
32	12 ¹ / ₂	354	...	...	...	1
32	13	453	...	...	...	1
32	13	434	...	411- 474	...	3
33	13	...	...	...	...	...
34	13 ¹ / ₂	484	...	445- 524	...	2
34	13 ¹ / ₂	468	482	432- 481	...	3
35	14 ¹ / ₈	493	514	439- 559	...	5
35	14 ¹ / ₈	582	561	552- 616	20·5	4
35	14 ¹ / ₈	598	586	518- 630	...	4
36	14 ¹ / ₂	579	595	538- 658	...	4
37	14 ¹ / ₂	608	611	566- 651	...	2
37	14 ¹ / ₂	647	638	559- 694	...	4
38	15 ¹ / ₈	658	678	559- 715	...	7
38	15 ¹ / ₈	718	697	616- 779	...	5
38	15 ¹ / ₈	715	736	651- 779	...	4
39	15 ¹ / ₂	775	754	757- 821	...	4
40	16 ¹ / ₈	772·6	763	644- 871	...	7
40	16 ¹ / ₈	740	788	694- 786	26·1	2
41	16 ¹ / ₂	852	829	729- 991	...	9
41	16 ¹ / ₂	896	872	835- 991	...	7
41	16 ¹ / ₂	868	894	793- 942	...	4

LEMON—continued.

Length.		Weight in Grammes.			Average Weight in Ounces.	No. of Fish.
In Cm.	In Inches.	Average.	Smoothed Average.	Range.		
42	1 ³ / ₈	917	922	871- 963	...	2
.5	...	982	...	935-1026	...	3
43	1 ⁷ / ₈	...	1038	...	...	...
.5	...	...	...	...	...	...
44	17 ³ / ₈	1094	...	1062-1126	38.6	2
.5	...	...	1096	...	...	...
45	2	1076	...	...	...	1
.5	...	1119	...	...	...	1
46	18 ³ / ₈	...	...	...	...	...
.5	...	...	...	...	...	...
47	1 ¹ / ₂	...	...	...	...	...

WITCH.

4	1 ³ / ₈	.19	...	.18- .21	...	3
.5	...	.28	.30	.21- .32	...	9
5	2	...	.45	...	...	...
.5	...	.64	.60	...	...	1
6	2 ¹ / ₈	.71	.77	.7 - .72	...	2
.5	...	.95	.93	.9 - 1.0	...	2
7	2 ³ / ₈	...	1.14	...	...	...
.5	...	1.33	1.31	1.2 - 1.5	...	3
8	3 ¹ / ₈	...	1.46	...	...	...
.5	...	1.6	...	...	...	1
9	2 ³ / ₈	...	...	...	...	...
.5	...	...	...	...	...	...
10	4 ¹ / ₈	...	...	...	...	...
.5	...	...	...	...	...	...
11	4 ⁵ / ₈	...	...	...	...	...
.5	...	...	...	...	...	...
12	5 ¹ / ₈	...	...	...	...	...
.5	...	8.4	...	...	...	1
13	5 ³ / ₈	10.6	9.87	...	...	1
.5	...	10.6	10.87	...	...	1
14	6 ¹ / ₈	11.4	11.7	9.4 - 12.8	...	5
.5	...	13.0	12.9	11.7 - 14.3	...	7
15	7 ¹ / ₈	14.3	14.07	13.0 - 15.1	.5	7
.5	...	14.9	15.53	13. - 18.4	...	10
16	6 ³ / ₈	17.4	16.9	16.2 - 18.8	...	5
.5	...	18.4	18.37	15.6 - 20	...	9
17	7 ³ / ₈	19.3	20.07	17.1 - 21.1	...	4
.5	...	22.5	21.4	18.1 - 22.3	...	6
18	7 ⁵ / ₈	22.4	23.3	...	...	1
.5	..	25.1	25.3	23. - 26.1	...	5

WITCH—continued.

Length.		Weight in Grammes.			Average Weight in Ounces.	No. of Fish.
In Cm.	In Inches.	Average.	Smoothed Average.	Range.		
19	$\frac{1}{2}$	28.3	28.3	27.5 - 29.	...	2
.5	...	31.38	31.6	28.45- 34.3	...	2
20	$\frac{7}{8}$	35.2	35.4	35 - 35.5	1.2	2
.5	...	...	39.7	...	...	...
21	$8\frac{1}{4}$	47.2	44.0	47.5 - 46.9	...	2
.5	...	45.0	47.7	43 - 47	...	2
22	$1\frac{1}{2}$	50.9	51.3	41 - 56.3	...	5
.5	...	57.9	58.9	...	...	1
23	$9\frac{1}{8}$	68	63.9	...	...	1
.5	...	65.9	69.2	60 - 84	...	4
24	$7\frac{7}{8}$	73.7	73.6	70 - 78	...	3
.5	...	78.0	80.3	70 - 88	...	9
25	$\frac{7}{8}$	89.1	86.1	79.3 - 69.5	3.1	5
.5	...	97.3	95.0	89.5 -108	...	4
26	$10\frac{1}{4}$	98.	99.3	88.3 -108	...	4
.5	...	102	106.2	89 -109.5	...	6
27	$\frac{8}{8}$	118	117.0	111 -127	...	4
.5	...	130.9	127.7	103 -150	...	10
28	11	134.2	137.0	127 -140	...	6
.5	...	146	144.1	132.3 -157	...	3
29	$7\frac{7}{8}$	152.2	153.7	137.4 -163	...	10
.5	...	162.8	164.3	144 -189	...	6
30	$1\frac{1}{2}$	178	170.4	164 -186	6.3	6
.5	...	170.4	179.8	160.8 -178	...	4
31	$12\frac{1}{4}$	191	192.9	163 -216	...	6
.5	...	217.3	210.4	208 -231	...	3
32	$\frac{8}{8}$	222.8	224.0	219 -234	...	6
.5	...	232	229.8	206 -255	...	5
33	13	234	237.7	213 -263	...	6
.5	...	247.3	249.7	212 -277	...	10
34	$\frac{8}{8}$	267.7	262	236 -297	...	4
.5	...	271.0	274.9	255 -298	...	10
35	$\frac{3}{4}$	285.9	283.5	262 -326	10.1	11
.5	...	293.5	297.2	255 -343	...	9
36	$14\frac{3}{8}$	312.2	308	305 -361	...	13
.5	...	318.2	320.1	314 -340	...	8
37	$7\frac{7}{8}$	330.0	337.1	312 -361	...	7
.5	...	363.1	353	326 -396	...	14
38	$1\frac{1}{2}$	366.0	370	312 -425	...	13
.5	...	381	391	305 -467	...	15
39	$15\frac{3}{8}$	426.2	414	397 -460	...	6
.5	...	435	440	397 -489	...	8
40	$\frac{3}{4}$	458.5	458	418 -500	16.2	4
.5	...	481	476.3	459 -531	...	3
41	$16\frac{1}{8}$	480	487.3	418 -574	...	12

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COMMON

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12	...	14.6	14.7	13.0 - 16	...	11
5	...	16.6	16.4	14.5 - 18.5	...	24
13	5½	18.0	18.4	16.5 - 20.1	...	10
5	...	20.6	20.9	19 - 22.5	...	8
14	½	24.2	23.7	20.5 - 27.8	...	6
5	...	26.4	26.2	23.5 - 33.7	...	12
15	½	28.0	28.1	23.5 - 32	1	8
5	...	30.0	30.0	25 - 34.1	...	6
16	6½	33.4	34.3	21 - 37	...	11
5	...	39.4	39.0	36.7 - 44.6	...	9
17	1½	44.1	43.1	42.4 - 47.1	...	3
5	...	46.0	46.3	40.5 - 59	...	10
18	7½	48.9	50.4	41.5 - 59.2	...	4
5	...	56.2	56.7	52 - 64	...	4
19	½	65.0	62.4	59 - 78	...	7
5	...	66.0	69.2	64 - 69	...	4
20	½	76.6	74.7	73 - 85	2.7	9
5	...	81.6	82.7	71 - 90	...	7
21	8½	90.0	90.3	77 - 99	...	4
5	...	99.4	99.4	82 - 136	...	11
22	1½	108.7	104.9	91 - 135	...	10
5	...	106.6	115.1	98 - 129	...	9
23	9½	129.9	123.5	120 - 141	...	8
5	...	133.9	136.2	111 - 149	...	15
24	7½	144.9	142.3	123 - 173	...	11
5	...	148.0	153.6	131 - 172	...	7
25	½	167.9	163.8	148 - 191	1.7	8
5	...	174.4	177.6	141 - 198	...	9
26	10½	190.5	186.9	170 - 219	...	10
5	...	195.8	198.7	171 - 219	...	5
27	½	209.9	210.9	170 - 247	...	8
5	...	217.6	224.3	180 - 262	...	11
28	11	240.7	238.9	191 - 276	...	6
5	...	257.3	254.0	205 - 297	...	9
29	1½	269.0	266.4	247 - 291	...	7
5	...	285.4	280.6	262 - 318	...	8
30	1½	279.4	296.4	246 - 300	9.8	5
5	...	311	305.3	247 - 347	...	7
31	12½	327	315.3	304 - 366	...	5
5	...	323.5	323.4	311 - 333	...	4
32	½	335	328.4	304 - 363	...	6
5	...	370.7	353.2	304 - 396	...	6
33	13	336	379.9	325 - 347	...	2
5	...	...	402.8	...	...	...

COMMON DAB—continued.

Length.		Weight in Grammes.			Average Weight in Ounces.	No. of Fish.
In Cm.	In Inches.	Average.	Smoothed Average.	Range.		
34	$\frac{3}{8}$	455	422.9	450-460	...	2
.5	...	474.5	449.4	439-510	...	2
35	$\frac{1}{2}$	445.7	469.8	389-481	15.1	3
.5	...	468.7	479.1	389-573	...	4
36	$14\frac{3}{8}$	505	487	446-559	...	3
.5	...	...	501.2	...	...	...
37	$\frac{5}{8}$	514.3	522.9	446-552	...	3
.5	...	517	549.3	...	...	1
38	$1\frac{1}{8}$	...	577	...	...	...
.5	...	637	...	...	...	1
39	$15\frac{3}{8}$	...	...	...	...	...
.5	...	...	693.5	...	...	...
40	$\frac{3}{4}$	...	...	...	...	...
.5	...	750	...	...	26.5	1
41	$16\frac{1}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
42	$\frac{7}{8}$	...	...	...	...	...

FLOUNDER.

11	$4\frac{5}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
12	$\frac{3}{4}$	...	...	...	...	...
.5	...	...	...	...	...	...
13	$5\frac{1}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
14	$\frac{1}{2}$	...	...	...	...	...
.5	...	...	...	...	...	...
15	$\frac{7}{8}$	31.3	...	...	...	1
.5	...	...	...	...	...	...
16	$6\frac{5}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
17	$1\frac{1}{2}$	...	...	...	...	...
.5	...	...	...	...	...	...
18	$7\frac{1}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
19	$\frac{1}{2}$	...	...	...	...	...
.5	...	...	...	...	...	...
20	$\frac{1}{2}$	...	...	...	...	...
.5	...	78.7	...	66- 85	2.8	3
21	$8\frac{1}{4}$	...	85.4	...	...	...
.5	...	92	93.5	...	...	1
22	$1\frac{1}{2}$	...	103	...	...	...
.5	...	124	118	144-184	...	2

FLOUNDER—continued.

Length.		Weight in Grammes.			Average Weight in Ounces.	No. of Fish.
In Cm.	In Inches.	Average.	Smoothed Average.	Range.		
23	9 $\frac{1}{8}$	...	126·7	...	...	...
·5	...	...	135·5	...	...	...
24	9 $\frac{7}{8}$	...	141·2	...	...	...
·5	...	147	150	137-157	...	2
25	10	...	162	...	5·7	...
·5	...	...	170	...	...	...
26	10 $\frac{1}{2}$	177	176	170-184	...	2
·5	...	...	184	...	...	...
27	10 $\frac{3}{4}$	191	197·7	170-212	...	2
·5	...	219·5	209·3	219-220	...	2
28	11	218	223·1	184-234	...	4
·5	...	...	235·6	...	...	...
29	11 $\frac{1}{2}$	245·7	247·7	241-248	...	3
·5	...	...	261·8	...	...	...
30	12	276	279·4	...	9·8	1
·5	...	276	294·4	...	...	1
31	12 $\frac{3}{4}$	313·7	309·3	297-340	...	3
·5	...	...	324·4	...	...	...
32	12 $\frac{7}{8}$	308	340·5	304-312	...	2
·5	...	...	355·5	...	...	...
33	13	403	372·3	347-481	...	3
·5	...	...	400·9	...	...	...
34	13 $\frac{1}{2}$	420	410·2	382-453	...	3
·5	...	415·7	425·1	354-481	...	4
35	14	449·5	440·1	439-460	15·9	2
·5	...	...	458·2	...	...	...
36	14 $\frac{1}{2}$	467	482·8	...	...	1
·5	...	...	523·3	...	...	...
37	14 $\frac{3}{4}$	...	543·1	...	...	...
·5	...	580	561·1	538-623	...	2
38	15	588	583·9	...	...	1
·5	...	...	606·6	...	...	...
39	15 $\frac{1}{2}$	...	625·3	...	...	...
·5	...	...	643·9	...	...	...
40	15 $\frac{3}{4}$	662·5	683·5	560-765	23·4	2
·5	...	...	702·2	...	...	...
41	16	...	741·7	...	...	...
·5	...	...	781·3	...	...	...
42	16 $\frac{1}{2}$	821	...	...	...	1
·5	...	...	...	...	...	...

LITTLE SOLE.

Length.		Weight in Grammes.			Average Weight in Ounces.	No. of Fish.
In Cm.	In Inches.	Average.	Smoothed Average.	Range.		
6	2 $\frac{3}{8}$	...	...	...	...	...
.5	...	2.72	...	2.4- 3.0	.09	4
7	$\frac{3}{4}$	3.22	3.5	3.0- 3.4	...	6
.5	...	4.28	4.23	3.8- 4.8	...	9
8	3 $\frac{1}{8}$	5.18	5.20	4.3- 5.8	.18	5
.5	...	6.15	6.34	5.0- 7.3	...	2
9	3 $\frac{3}{8}$	7.7	7.53	6.9- 9.2	...	11
.5	...	8.75	9.18	7.8-10.0	.3	11
10	4 $\frac{1}{8}$	11.0	10.77	...	...	1
.5	...	12.57	12.96	12.1-13.2	...	3
11	4 $\frac{3}{8}$	14.4	13.96	...	...	1
.5	...	14.9	...	...	.5	1
12	$\frac{5}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
13	...	...	...	...	...	...
.5	...	...	...	...	...	...

TURBOT.

25	9 $\frac{1}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
26	10 $\frac{1}{4}$	...	...	...	...	...
.5	...	...	...	...	...	...
27	10 $\frac{3}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
28	11	...	...	...	...	...
.5	...	...	...	...	...	...
29	11 $\frac{1}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
30	11 $\frac{3}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
31	12 $\frac{1}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
32	12 $\frac{3}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
33	13	...	...	...	...	...
.5	...	810.5	...	750-871	...	2
34	13 $\frac{1}{8}$	828	...	...	29.2	1
.5	...	...	890	...	...	...
35	13 $\frac{3}{8}$	...	...	...	...	...
.5	...	951	...	828-1090	...	3
36	14 $\frac{1}{8}$	...	971	...	...	...
.5	...	991	1000	...	...	1

TURBOT—continued.

Length.		Weight in Grammes.			Average Weight in Ounces.	No. of Fish.
In Cm.	In Inches.	Average.	Smoothed Average.	Range.		
37	1 $\frac{3}{8}$	...	1039	...	...	...
.5	...	1034	1072	...	...	1
38	1 $\frac{5}{8}$	1143	1108	1090-1289	...	4
.5	...	1147	1155	...	...	1
39	15 $\frac{3}{8}$	1175	...	...	...	1
.5	...	...	...	...	...	...
40	1 $\frac{7}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
41	16 $\frac{1}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
42	1 $\frac{7}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
43	1 $\frac{7}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
44	17 $\frac{3}{8}$	1827	...	...	64.5	1
.5	...	...	...	...	...	...
45	1 $\frac{7}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
46	18 $\frac{1}{8}$	...	2173	...	...	...
.5	...	...	...	...	...	...
47	1 $\frac{7}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
48	1 $\frac{7}{8}$	...	...	...	...	...
.5	...	2520	...	...	...	1
49	19 $\frac{1}{8}$	...	2613	...	...	...
.5	...	...	...	...	...	...
50	1 $\frac{7}{8}$	2706	...	...	95.5	1
.5	...	...	...	...	...	...
51	20 $\frac{1}{8}$	...	...	...	...	...
.5	...	...	3052	...	...	...
52	1 $\frac{7}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
53	1 $\frac{7}{8}$	...	...	...	...	...
.5	...	3399	...	...	...	1
54	21 $\frac{1}{8}$	...	...	...	...	...
.5	...	...	3441	...	...	...
55	1 $\frac{7}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
56	22 $\frac{1}{8}$	3483	...	...	12.3	1
.5	...	...	...	...	...	...
57	1 $\frac{7}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
58	1 $\frac{3}{4}$	...	4300	...	...	...
.5	...	...	...	...	...	...
59	23 $\frac{1}{8}$	...	...	...	...	...

TURBOT—continued.

Length.		Weight in Grammes.			Average Weight in Ounces.	No. of Fish.
In Cm.	In Inches.	Average.	Smoothed Average.	Range		
60	23 ⁵ ₈	...	...	...	...	...
60	23 ⁵ ₈	5117	...	...	...	1
61	24	...	...	...	...	...
62	24 ¹ ₈	...	5217	...	...	...
63	25 ⁵ ₈	...	...	...	...	...
63	25 ⁵ ₈	5317	...	5288-5367	187.7	2
64	25	...	...	...	...	...
65	26 ⁵ ₈	...	...	...	...	...
66	26 ⁵ ₈	...	...	...	...	...
66	26 ⁵ ₈	...	6376	...	...	...
67	27 ¹ ₈	...	...	...	...	...
68	27 ⁵ ₈	...	...	...	...	...
69	28 ¹ ₈	6301	...	...	...	1
69	28 ¹ ₈	...	7435	...	...	...
70	27	8569	...	...	...	1
71	28 ⁵ ₈	...	8745	...	...	...
72	28 ⁵ ₈	8921	...	...	315	1
73	29 ⁵ ₈	...	...	...	...	...
74	29 ⁵ ₈	...	...	...	...	...
75	29 ⁵ ₈	...	10227	...	...	...
76	30 ⁵ ₈	...	...	...	...	...
77	30 ⁵ ₈	...	...	...	...	...
78	30 ⁵ ₈	...	...	...	...	...
78	30 ⁵ ₈	11533	...	10323-12121	407	4
79	31	...	...	...	...	...
80	31	...	...	...	...	...
81	31	...	...	...	...	...
82	31	...	...	...	...	...

BRILL.

Length.		Weight in Grammes.			Average Weight in Ounces.	No. of Fish.
In Cm.	In Inches.	Average.	Smoothed Average.	Range.		
25	...	...	...	...	...	...
.5	...	...	...	...	...	...
26	10 $\frac{1}{4}$	...	...	...	...	...
.5	...	248	...	...	...	1
27	9	301	283.7	243- 339	...	4
.5	...	...	302.2	...	...	...
28	11	315	320.6	312- 319	...	2
.5	...	344.7	337.1	319- 368	...	3
29	11 $\frac{3}{8}$	351.7	344.1	326- 389	...	3
.5	...	336	351.9	311- 361	...	2
30	11 $\frac{1}{2}$	368	360.5	347- 396	13.0	3
.5	...	377.5	380.9	328- 432	...	4
31	12 $\frac{3}{8}$	397.3	406.4	318- 481	...	6
.5	...	444.4	440.3	396- 552	...	5
32	9	478.4	471.0	411- 516	...	8
.5	...	490.2	495.3	474- 410	...	4
33	13	517.4	517.6	460- 552	...	5
.5	...	545.2	542	524- 580	...	4
34	9	...	562.9	...	...	...
.5	...	580.7	587.9	566- 595	...	3
35	9 $\frac{1}{4}$	...	622	...	...	...
.5	...	659.3	655	583- 729	23.3	3
36	14 $\frac{3}{8}$	...	683	...	...	...
.5	...	708	720	701- 715	...	2
37	14 $\frac{1}{2}$	...	769	...	...	...
.5	...	830	824	821- 839	...	3
38	15 $\frac{1}{8}$	...	873	...	...	...
.5	...	...	...	...	...	...
39	15 $\frac{3}{8}$	917	912	879- 962	...	4
.5	...	947	953	874- 984	...	4
40	16	995	978	935-1055	35.1	2
.5	...	991	1022	977-1005	...	2
41	16 $\frac{1}{2}$	1079	1052	1019-1140	...	2
.5	...	1085	...	981-1189	...	2
42	16 $\frac{3}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
43	17 $\frac{1}{8}$	1169	...	1097-1281	41.3	7
.5	...	...	...	...	...	...
44	17 $\frac{3}{8}$	...	...	...	...	...
.5	...	1373	...	...	...	1
45	18	...	...	...	...	...
.5	...	...	...	...	...	...
46	18 $\frac{1}{2}$	1503	...	1451-1557	53.1	3
.5	...	...	...	...	...	...
47	19	...	...	...	...	...

BRILL—continued.

Length.		Weight in Grammes.			Average Weight in Ounces.	No. of Fish.
In Cm.	In Inches.	Average.	Smoothed Average.	Range.		
48	19 ⁵ / ₈	1565	...	...	...	1
48	19 ⁵ / ₈	...	...	...	...	...
49	19 ⁵ / ₈	...	...	...	...	...
49	19 ⁵ / ₈	1940	...	1690-2181	68.5	2
50	20 ¹ / ₈	...	...	...	...	...
50	20 ¹ / ₈	...	...	...	...	...
51	20 ¹ / ₈	2145	...	...	...	1
51	20 ¹ / ₈	...	...	...	...	...
51	20 ¹ / ₈	2117	...	...	...	1
52	21 ¹ / ₈	2145	...	...	...	1
52	21 ¹ / ₈	...	...	...	...	...
53	21 ¹ / ₈	...	...	...	...	...
53	21 ¹ / ₈	...	...	...	...	...
54	21 ¹ / ₈	...	...	...	...	...
54	21 ¹ / ₈	...	...	...	...	...
54	21 ¹ / ₈	...	...	...	...	...

HALIBUT.

21	8 ¹ / ₂	...	...	...	...	...
21	8 ¹ / ₂	...	...	...	...	...
22	11	84	...	...	3.0	1
22	11	...	...	...	...	...
23	9 ¹ / ₈	...	...	...	...	...
23	9 ¹ / ₈	...	113.5	...	...	...
24	11 ¹ / ₈	...	...	...	...	...
24	11 ¹ / ₈	...	...	...	...	...
25	11 ¹ / ₈	143	...	...	5.0	1
25	11 ¹ / ₈	...	...	...	...	...
26	10 ¹ / ₄	153	148	...	...	...
26	10 ¹ / ₄	...	169.2	...	...	1
26	10 ¹ / ₄	...	...	...	...	...
27	11	...	...	...	...	...
27	11	171	...	...	...	1
28	11	196	190.3	192-201	6.9	2
28	11	...	...	...	...	...
29	11 ¹ / ₈	204	...	...	...	1
29	11 ¹ / ₈	...	238	...	...	...
29	11 ¹ / ₈	...	...	...	...	...
30	11 ¹ / ₈	272	...	...	9.6	1
30	11 ¹ / ₈	...	...	...	...	...
31	12 ¹ / ₈	...	...	...	...	...
31	12 ¹ / ₈	...	...	...	...	...
32	13	...	...	...	...	...
32	13	...	...	...	...	...
32	13	...	...	...	...	...
33	13	...	355.5	...	...	...
33	13	...	...	...	...	...
34	11 ¹ / ₈	...	...	...	...	...



HALIBUT—continued.

Length.		Weight in Grammes.			Average Weight in Ounces.	No. of Fish.
In Cm.	In Inches.	Average.	Smoothed Average.	Range.		
100	39½	...	...	...	372	1
100	...	10534	10501	...	...	...
101	...	...	...	10478-11385	..	3
101	...	9230	10468	...	...	1
102	40½	10591	...	...	...	1
103	...	...	...	...	...	...
103	...	...	12597	...	444.8	...
104	40½	...	...	...	...	...
105	...	...	...	...	...	...
105	...	...	...	...	...	...
105	...	14726	...	...	...	1
112	44½	...	...	...	...	...
112	...	14839	...	...	524	1
113	...	...	...	...	...	...
119	...	...	...	...	...	...
119	...	18271	...	17252-19291	...	2
120	47½	20787	20152	...	...	1
120	...	...	20399	...	...	...
121	...	20844	20979	...	736	1
121	...	21693	21399	...	...	1
122	48	...	22090	...	...	...
122	...	...	22288	...	...	...
123	...	22487	...	...	..	1
126	49½	...	...	...	...	...
126	...	28150	...	...	...	1
134	52¾	25375	...	...	...	1
134	...	...	27414	...	968	...
135	...	29453	...	...	...	1
LONG ROUGH DAB.						
4	1½	.33	...	...	...	1
4	...	.51	...	.49- .53	...	2
5	2	...	...	...	...	...
5	...	.97	...	.89- .1	...	4
6	2½	1.2	1.3	1.1 - 1.4	.04	5
6	...	1.6	1.53	1.2 - 1.85	...	9
7	3	1.86	1.93	1.7 - 2.0	...	15
7	...	2.26	2.31	1.9 - 2.8	...	18
8	3½	2.76	2.68	2.4 - 3.1	.09	16

LONG ROUGH DAB—continued.

Length.		Weight in Grammes.			Average Weight in Ounces.	No. of Fish.
In Cm.	In Inches.	Average.	Smoothed Average.	Range.		
.5	...	3.1	3.55	2.9 - 3.7	...	7
9	$1\frac{1}{8}$	4.35	3.9	3.9 - 5.0	...	6
.5	...	4.8	4.97	4.1 - 6.0	...	11
10	$1\frac{1}{8}$	5.6	5.7	4.6 - 6.8	.2	17
.5	...	6.6	6.5	5.4 - 7.8	...	20
11	$4\frac{1}{8}$	7.3	7.85	5.6 - 8.6	...	20
.5	...	9.1	8.41	6.8 - 10.5	...	13
12	$\frac{3}{4}$	9.5	10.5	7.9 - 11.7	...	14
.5	...	11.9	11.6	9.9 - 13.6	...	14
13	$5\frac{1}{8}$	13.8	13.3	12.9 - 15.6	...	11
.5	...	14.8	15.5	12.2 - 18.2	...	16
14	$\frac{1}{2}$	17.3	16.5	14.2 - 19.7	...	12
.5	...	18.2	20.0	17 - 20	...	5
15	$\frac{7}{8}$	22.8	21.6	18.3 - 24.9	.8	5
.5	...	25.0	25.3	23.7 - 26.4	...	9
16	$6\frac{1}{8}$	27.9	27.2	25.4 - 33.1	...	7
.5	...	29.38	30.1	25.6 - 32.7	...	10
17	$1\frac{1}{8}$	32.3	32.4	27.4 - 38	...	14
.5	...	35.2	35.9	32 - 39.2	...	5
18	$7\frac{1}{8}$	39.5	40.4	34.7 - 47.4	1.4	9
.5	...	45.7	43.8	41.9 - 50.7	...	5
19	$\frac{1}{2}$	48.1	50.5	45 - 52.1	...	6
.5	...	55.3	53.7	42 - 58.5	...	8
20	$\frac{7}{8}$	59.4	58.5	56 - 61.4	2.1	4
.5	...	61.7	...	56.9 - 66.5	...	2
21	$8\frac{1}{4}$	...	68.6	...	...	...
.5	...	77.8	74.2	...	...	1
22	$1\frac{1}{8}$	86.8	83.6	81.4 - 96	...	5
.5	...	89.4	96.4	81.8 - 97	...	2
23	$9\frac{1}{8}$	106.0	103.2	105 - 107	...	2
.5	...	117	114.0	...	...	1
24	$1\frac{7}{8}$	122	...	121 - 123	4.3	2
.5	...	...	...	...	...	...
25	$\frac{7}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
26	$10\frac{1}{4}$	168	...	...	5.9	1
.5	...	170	...	...	...	1
27	$\frac{5}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
28	11	...	...	...	...	...
.5	...	...	...	...	...	...
29	$1\frac{7}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...

WHITING.

Length.		Weight in Grammes.			Average Weight in Ounces.	No. of Fish.
In Cm.	In Inches.	Average.	Smoothed Average.	Range.		
6	2 $\frac{1}{8}$	1.5	...	...	...	1
.5	...	...	...	...	...	...
7	$\frac{3}{4}$	...	..	...	...	...
.5	...	3.4	...	...	...	1
8	3 $\frac{1}{8}$	...	...	...	...	...
.5	...	4.3	...	3.9 - 4.6	...	4
9	1 $\frac{3}{8}$	5.1	5.1	4.4 - 5.8	...	7
.5	...	6.0	5.8	5.4 - 6.4	...	12
10	1 $\frac{1}{2}$	7.4	7.1	6.8 - 8.8	.26	5
.5	...	8.0	8.2	7.3 - 8.5	...	8
11	4 $\frac{1}{8}$	9.25	9.2	8.0 - 11.12	...	6
.5	...	10.4	10.8	9.8 - 10.9	...	8
12	$\frac{3}{4}$	12.8	12.4	11.4 - 17.6	...	7
.5	...	14.1	14.1	13.3 - 15.4	...	7
13	5 $\frac{1}{8}$	15.5	15.8	13.4 - 17.5	...	11
.5	...	17.7	17.4	16.5 - 20.2	...	11
14	$\frac{1}{2}$	19.0	19.3	17.1 - 20.5	...	10
.5	...	21.1	21.1	17.6 - 24	...	10
15	$\frac{7}{8}$	23.3	23.8	22 - 27	.8	6
.5	...	27.0	26.6	24 - 33.5	...	6
16	6 $\frac{1}{8}$	29.6	29.3	26.5 - 33.5	...	7
.5	...	31.4	32.2	29.5 - 34.8	...	3
17	1 $\frac{1}{4}$	35.6	35.2	32 - 38.5	...	4
.5	...	38.6	38.2	33 - 44	...	5
18	7 $\frac{1}{8}$	40.5	41.3	36.4 - 47	...	8
.5	...	...	44.1	...	...	...
19	$\frac{1}{2}$	47.1	47.8	40.5 - 52	...	5
.5	...	...	50.7	...	...	...
20	$\frac{7}{8}$	53.2	54.0	49.5 - 58.6	1.5	5
.5	...	58.6	57.7	50.7 - 71	...	4
21	8 $\frac{1}{8}$	61.3	62.1	52 - 68.6	...	11
.5	...	66.5	67.3	66 - 67	...	2
22	1 $\frac{1}{2}$	74.1	72.7	64 - 85	...	9
.5	...	77.4	79.1	65 - 88	...	19
23	9 $\frac{1}{8}$	85.7	85.6	72 - 95	...	14
.5	...	94.1	93.9	82 - 101	...	19
24	1 $\frac{7}{8}$	102.4	102.4	83 - 111	...	12
.5	...	110.6	110.6	101 - 133	...	9
25	$\frac{7}{8}$	118	118.2	102 - 134	4.2	15
.5	...	125.2	127.3	107 - 149	...	14
26	10 $\frac{1}{4}$	137.7	136.1	121 - 158	...	10
.5	...	145.4	146.1	136 - 157	...	9
27	$\frac{5}{8}$	155.1	157.6	154 - 177	...	12
.5	...	172.4	168.1	148 - 190	...	14
28	11	176.9	178.1	157 - 213	...	14

WHITING—continued.

Length.		Weight in Grammes.			Average Weight in Ounces.	No. of Fish.
In Cm.	In Inches.	Average.	Smoothed Average.	Range.		
.5	...	185.2	187.7	159 -205	...	6
29	7 $\frac{7}{8}$	191.0	193.8	165 -205	...	14
.5	...	205.1	202.2	199 -213	...	7
30	11 $\frac{1}{8}$	210.6	213.6	188 -228	7.6	11
.5	...	225	225	223 -255	...	7
31	12 $\frac{3}{8}$	239.4	237	217 -276	...	13
.5	...	247	252.5	252 -273	...	9
32	12 $\frac{1}{2}$	271	264	242 -331	...	8
.5	...	274	272	256 -312	...	10
33	13	270	279	...	...	4
.5	...	293	292	263 -354	...	9
34	13 $\frac{1}{2}$	312	309	306 -361	...	6
.5	...	...	322	...	...	...
35	14	332	332	298 -411	12.0	8
.5	...	...	341	...	...	...
36	14 $\frac{3}{8}$	351	357	...	...	...
.5	...	378	378	341 -432	...	8
37	15 $\frac{1}{8}$	...	...	...	...	...
.5	...	...	392	...	...	...
38	15 $\frac{1}{2}$	407	407	...	...	2
.5	...	430	428	400 -524	...	4
39	15 $\frac{3}{4}$	446	462	404 -524	...	5
.5	—	509	504	474 -545	...	2
40	16	513	...	...	...	1
.5	...	538	542	...	...	1
41	16 $\frac{1}{2}$	546	...	...	...	7
.5	...	...	586	...	...	...
42	17 $\frac{1}{8}$	...	...	...	...	...
.5	...	613	...	517 -680	...	4
43	17 $\frac{1}{2}$	...	...	...	...	...
.5	...	...	...	...	...	...
44	17 $\frac{3}{4}$	569	...	...	...	1
.5	...	...	...	...	...	...
45	18	...	...	...	...	...
.5	...	...	...	...	...	...
46	18 $\frac{1}{2}$	...	...	...	...	...
.5	...	...	...	...	...	...
47	19	903	...	...	...	1
.5	...	859	893	723 -977	...	3
48	19 $\frac{1}{8}$	984	...	...	...	1
.5	...	...	...	...	...	...
49	19 $\frac{3}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...

HADDOCK.

Length.		Weight in Grammes.			Average Weight in Ounces.	No. of Fish.
In Cm.	In Inches.	Average.	Smoothed Average.	Range.		
6	2 $\frac{3}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
7	$\frac{3}{4}$	...	...	...	...	...
.5	...	...	...	...	...	...
8	3 $\frac{1}{8}$	...	...	...	...	...
.5	...	4.6	...	...	16	1
9	1 $\frac{1}{2}$	...	5.3	...	...	...
.5	...	6.1	6.3	5.6 - 6.6	22	5
10	4 $\frac{1}{8}$	7.2	7.8	7.0 - 7.4	25	2
.5	...	9.1	8.8	8 - 9.8	...	8
11	4 $\frac{1}{2}$	10.2	10.8	9.6 - 11.5	...	4
.5	...	12.0	11.9	11.1 - 12.7	...	12
12	$\frac{3}{4}$	13.5	13.6	12.1 - 14.5	...	9
.5	...	15.4	15.4	14.6 - 16.5	...	8
13	5 $\frac{1}{8}$	17.2	17.6	16 - 18.2	...	10
.5	...	20.1	19.8	18.2 - 23.6	...	12
14	$\frac{1}{2}$	22.1	22.6	20 - 25.5	...	8
.5	...	25.5	25.2	22.9 - 31.2	...	17
15	$\frac{7}{8}$	28.0	28.3	24 - 30.3	99	16
.5	...	31.4	31.0	29.8 - 35	...	16
16	6 $\frac{1}{8}$	33.7	33.8	31.6 - 35.1	...	12
.5	...	36.3	36.6	32.3 - 40.3	...	16
17	1 $\frac{1}{8}$	39.8	39.7	36.6 - 43.5	...	21
.5	...	43.0	44.0	38 - 48.5	...	19
18	7 $\frac{1}{8}$	49.2	48.3	44 - 53.5	...	22
.5	...	52.7	53.0	48.1 - 59	...	28
19	$\frac{1}{2}$	57.2	56.5	51.8 - 61	...	18
.5	...	59.7	61.4	55.2 - 68.3	...	13
20	$\frac{7}{8}$	67.4	65.7	64.2 - 73	2.4	11
.5	...	70.1	70.3	68.6 - 71	...	3
21	8 $\frac{1}{4}$	73.3	75.4	72.4 - 76	...	6
.5	...	...	82.8	...	...	...
22	1 $\frac{1}{8}$	92.7	91.4	91.6 - 94.5	...	3
.5	...	98.8	97.4	90.5 - 106.3	...	3
23	9 $\frac{1}{8}$	100.7	102.6	96.5 - 105	...	2
.5	...	108.3	109.3	99.5 - 122.5	...	10
24	1 $\frac{7}{8}$	119.0	118.3	112 - 127	...	3
.5	...	127.6	128.7	114.5 - 135.6	...	7
25	$\frac{7}{8}$	142.5	140.2	126 - 162	5.03	15
.5	...	150.5	150.2	131.6 - 177	...	23
26	10 $\frac{1}{4}$	157.5	157.3	138 - 184	...	24
.5	...	164.0	165.6	148 - 184	...	23
27	8	175.3	174.6	161 - 206	...	30
.5	...	184.4	184.1	162 - 206	...	19
28	11	192.7	194.9	176 - 219	...	17

HADDOCK—continued.

Length.		Weight in Grammes.			Average Weight in Ounces.	No. of Fish.
In Cm.	In Inches.	Average.	Smoothed Average.	Range.		
.5	...	207.7	205.5	170-229	...	17
29	1 $\frac{7}{8}$	216.0	217.2	198-238	...	13
.5	...	227.8	228.4	207-267	...	14
30	1 $\frac{1}{8}$	241.4	243.3	213-269	8.5	18
.5	...	260.7	256.0	241-284	...	14
31	12 $\frac{3}{8}$	265.8	271.7	238-304	...	9
.5	...	288.5	281.4	240-347	...	9
32	8	289.9	293.0	255-307	...	8
.5	...	300.6	305.1	247-347	...	19
33	13	324.8	319.0	276-368	...	13
.5	...	332.7	336.1	297-385	...	9
34	8	350.9	349.9	311-412	...	20
.5	...	366.2	367.2	325-432	...	15
35	4	384.5	381.0	318-432	13.6	12
.5	...	402.3	405.8	325-496	...	12
36	14 $\frac{3}{8}$	430.7	425.2	361-517	...	14
.5	...	442.5	445.0	389-510	...	10
37	1 $\frac{7}{8}$	461.8	465.9	420-509	...	10
.5	...	493.3	485.9	432-588	...	12
8	1 $\frac{1}{8}$	502.5	515.6	417-559	...	12
.5	...	550.9	542.1	467-616	...	7
39	15 $\frac{1}{8}$	572.8	571.6	523-637	...	5
.5	...	591	579.1	530-641	...	7
40	4	573.5	591.6	573-574	20.25	2
.5	...	610.3	604.9	523-696	...	11
41	16 $\frac{1}{8}$	631	636.4	549-736	...	5
.5	...	667.9	681.2	566-782	...	10
42	1 $\frac{7}{8}$	...	698.8	...	...	...
.5	...	744.7	731.5	722-785	...	3
43	1 $\frac{1}{8}$	751.7	750.1	715-864	...	9
.5	...	754	767.9	750-759	...	2
44	17 $\frac{1}{8}$	798	777.6	730-892	...	4
.5	...	780	802.3	715-850	...	4
45	4	...	828.2	...	29.2	...
.5	...	878	854.1	...	...	1
46	18 $\frac{1}{8}$	856	873.8	...	...	1
.5	...	887	934.4	729-1027	...	3
47	1	1060	1013.5	870-1191	...	3
.5	...	...	1046	...	...	...
48	7	1033	1042	976-1090	...	2
.5	...	...	1048	...	...	...
49	19 $\frac{3}{8}$	1063	1095	948-1182	...	4
.5	...	...	1117	...	...	...
50	1 $\frac{1}{8}$	...	1171	...	41.3	...
.5	...	...	...	...	...	...

HADDOCK—continued.

Length.		Weight in Grammes.			Average Weight in Ounces.	No. of Fish.
In Cm.	In Inches.	Average.	Smoothed Average.	Range.		
.5	...	...	...	...	...	...
74	1 $\frac{1}{8}$	3691	...	3002-4290	...	3
.5	...	...	...	...	...	...
75	29 $\frac{1}{8}$	...	...	...	...	...
COD.						
2	1 $\frac{1}{8}$	...	...	...	...	...
.5	...	.11	...	...	...	1
3	1 $\frac{3}{8}$	.18	...	...	...	1
.5	...	.37	...	...	...	1
4	1 $\frac{5}{8}$	.65	...	.63- .67	...	2
.5	...	...	...	...	...	...
5	2	1.04	...	1.01 1.07	...	2
.5	...	...	...	...	...	...
6	2 $\frac{1}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
7	2 $\frac{3}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
8	3 $\frac{1}{8}$	4.4	...	4.3 - 4.4	...	3
.5	...	4.65	5.01	4.6 - 4.7	...	2
9	3 $\frac{3}{8}$	6.0	5.78	5.4 - 6.8	...	4
.5	...	6.7	6.83	6.2 - 7.6	...	8
10	3 $\frac{5}{8}$	7.8	7.93	7.1 - 8.9	0.3	7
.5	...	9.3	9.47	8.4 - 10.2	...	4
11	4 $\frac{1}{8}$	11.3	11.10	10.3 - 11.9	...	12
.5	...	12.7	13.1	11.7 - 13.5	...	9
12	4 $\frac{3}{8}$	15.2	15.0	14.3 - 16.5	...	5
.5	...	17.1	17.3	16.2 - 17.8	...	11
13	5 $\frac{1}{8}$	19.7	19.7	16.8 - 20.7	...	9
.5	...	21.3	21.8	19 - 22.4	...	11
14	5 $\frac{3}{8}$	24.6	24.6	21 - 29	...	7
.5	...	27.8	27.8	24.6 - 30.6	...	10
15	5 $\frac{5}{8}$	31.1	30.7	30 - 31.6	1.1	4
.5	...	33.3	34.0	30.2 - 35.5	...	4
16	6 $\frac{1}{8}$	37.6	37.5	34 - 40.5	...	4
.5	...	41.7	41.2	40.5 - 43	...	2
17	6 $\frac{3}{8}$	44.4	45.4	40.4 - 47.8	...	5
.5	...	50.0	49.3	45.6 - 54.5	...	2
18	7 $\frac{1}{8}$	53.5	54.0	50 - 56	...	3
.5	...	58.5	57.9	58 - 59	...	2
19	7 $\frac{3}{8}$	61.7	62.9	59.4 - 64	...	2
.5	...	68.5	66.8	68 - 69	...	2

1

COD—continued.

Length.		Weight in Grammes.			Average Weight in Ounces.	No. of Fish.
In Cm.	In Inches.	Average.	Smoothed Average.	Range.		
65	$\frac{3}{8}$	...	2569	...	90.7	...
.5	...	2588	2598	2153-2838	...	3
66	$25\frac{1}{4}$	2638	2680	...	...	...
.5	...	...	2744	2471-2818	...	3
67	$26\frac{1}{8}$	2914	2878	2740-3151	..	4
.5	...	...	2975	...	...	...
68	$\frac{1}{8}$	3037	3027	2945-3144	...	4
.5	...	...	3069	...	...	...
69	$1\frac{1}{4}$	3101	3116	...	...	1
.5	...	3179	3233	3038-3384	...	3
70	$27\frac{3}{8}$	3420	3380	...	120.7	1
.5	...	...	3488	...	...	...
71	$\frac{3}{4}$	3557	3581	3413-3639	...	3
.5	...	...	3697	...	...	...
72	$28\frac{1}{8}$	3738	3865	...	...	1
.5	...	4161	...	3646-4418	...	4
73	$\frac{1}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
74	$1\frac{1}{4}$	...	..	...	...	...
.5	...	4074	...	3951-4149	...	3
75	$29\frac{1}{8}$	4000	...	3823-4178	141	2
.5	...	...	...	...	...	...
76	...	...	...	...	...	...
.5	...	...	...	...	...	...
77	...	4602	...	4276-4928	...	2
.5	...	...	...	...	...	...
78	...	...	...	...	...	...
.5	...	...	...	...	...	...
79	...	4985	...	4312-5607	...	7
.5	...	...	...	...	...	...
80	...	...	...	...	...	...
.5	...	...	...	...	...	...
81	...	...	...	...	...	...
.5	...	5501	...	4027-6542	...	3
82	...	...	...	...	...	...
.5	...	6514	...	...	230	1
83	...	...	...	...	...	...
.5	...	...	...	..	...	...
84	...	...	...	...	...	...
.5	...	6655	...	6202-7193	...	3
85
.5
86
.5	...	6542	...	6485-6599	...	2
87

of the Fishery Board for Scotland.

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COD—*continued.*

COD—continued.

Length.		Weight in Grammes.			Average Weight in Ounces.	No. of Fish.
In Cm.	In Inches.	Average.	Smoothed Average	Range.		
110	...	...	...	...	...	...
111	...	...	...	...	...	...
112	...	...	...	...	...	...
110·5	...	...	...	...	...	...
111·5	...	...	...	...	...	...
112·5	...	...	...	...	...	...
THE NORWAY POUT.						
3	1½	·315	...	·29— ·34	...	2
3·5	...	...	...	...	...	...
4	1½	...	...	...	...	...
4·5	...	...	...	...	...	...
5	2	...	...	...	...	...
5·5	...	...	...	...	...	...
6	2½	...	...	...	...	...
6·5	...	...	...	...	...	...
7	2¾	2·5	...	...	·09	1
7·5	...	2·9	2·84	...	...	1
8	3½	3·13	3·19	...	...	1
8·5	...	3·55	3·75	3·2 — 3·8	...	4
9	3¾	4·58	4·56	3·2 — 5·3	...	13
9·5	...	5·55	5·49	4·7 — 6·4	...	13
10	4¼	6·35	6·69	5·5 — 7·0	·2	11
10·5	...	7·18	7·38	5·3 — 8·7	...	19
11	4½	8·6	8·10	7·3 — 9·6	...	14
11·5	...	9·7	9·7	7·3 — 10·9	...	17
12	4¾	10·8	10·87	10·3 — 11·8	·3	9
12·5	...	12·1	12·41	10·9 — 12·9	...	7
13	5¼	14·34	13·81	12·7 — 15·2	...	5
13·5	...	15	15·81	12·4 — 17·2	...	11
14	5½	18·1	17·87	17·2 — 19·2	...	8
14·5	...	20·5	20·57	17·8 — 26·5	...	14
15	6	23·1	23·5	18·0 — 28·2	·8	15
15·5	...	27·0	26·27	23·6 — 20·9	...	10
16	6¾	28·7	29·1	23·1 — 31·7	...	16
16·5	...	31·5	31·8	28·7 — 35·8	...	7
17	7¼	35·1	34·98	38 — 38·4	...	3
17·5	...	38·34	37·9	35·7 — 41·4	...	5
18	7½	40·3	41·2	33·3 — 47·0	1·4	5
18·5	...	44·9	44·6	...	...	1
19	8	48·7	50·3	47·4 — 50·1	...	2
19·5	...	57·2	...	57·2 — 57·3	...	2
19·8	...	60·0	...	...	2·1	1
20·2	...	67·1	...	...	...	1

GURNARD.

Length.		Weight in Grammes.			Average Weight in Ounces.	No. of Fish.
In Cm.	In Inches.	Average.	Smoothed Average.	Range.		
4	1 $\frac{9}{16}$	...	...	...	...	...
.5	...	.71	...	.65- .77	...	2
5	2	...	.48	...	...	...
.5	...	1.25	1.13	1.2 - 1.3	.04	2
6	2 $\frac{3}{8}$	...	1.65	...	...	...
.5	...	2.05	2.19	...	...	1
7	2 $\frac{7}{8}$	2.87	2.64	2.75- 3.0	...	2
.5	...	3.0	3.27	2.9 - 3.1	...	2
8	3 $\frac{1}{8}$	3.93	...	3.6 - 4.2	...	3
.5	...	...	...	...	...	...
9	3 $\frac{9}{16}$	...	...	...	...	...
.5	...	5.93	...	5.6 - 6.6	...	3
10	4 $\frac{1}{8}$	6.3	6.97	...	.2	1
.5	...	8.7	8.3	...	...	1
11	4 $\frac{5}{8}$	10.0	9.87	...	...	1
.5	...	10.9	...	10.2 - 12.0	.38	3
12	4 $\frac{3}{4}$	...	...	...	...	...
.5	...	...	...	...	...	...
13	5 $\frac{1}{8}$	..	...	...	...	...
.5	...	...	...	...	...	...
14	5 $\frac{1}{2}$	...	...	...	...	...
.5	...	...	...	...	...	...
15	5 $\frac{7}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
16	6 $\frac{1}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
17	6 $\frac{3}{4}$	...	...	...	...	...
.5	...	49.3	...	44 - 54	1.7	3
18	7 $\frac{1}{8}$	..	...	...	...	...
.5	...	...	...	...	...	...
19	7 $\frac{1}{2}$	61	...	...	...	1
.5	...	...	...	...	...	...
20	7 $\frac{7}{8}$	...	...	...	...	...
.5	...	...	...	...	...	...
21	8 $\frac{1}{4}$	82	...	...	...	1
.5	...	85	83.3	85 - 85	3.0	2
22	8 $\frac{3}{4}$	83.5	85.8	79 - 88	...	2
.5	...	...	89	...	...	...
23	9 $\frac{1}{8}$	95	93	...	...	1
.5	...	95	101	...	...	1
24	9 $\frac{3}{8}$	113.5	112	107 - 120	...	2
.5	...	...	124	...	...	...
25	9 $\frac{7}{8}$	135	132	...	4.7	1
.5	...	...	138	...	...	...
26	10 $\frac{1}{4}$	141	...	132 - 148	...	3

27	5	...	...	157.7	...	...	...
27	5	...	174.7	...	183	-183	...
28	11	...	...	177.1	...	...	...
28	5	...	179.6	...	170	-186	...
29	7	...	...	...	...	...	5
30	5	...	...	...	...	...	...
30	5	...	227.0	...	205	-255	8.0
30	5	...	237	235	...	...	1
31	12	...	...	249	...	...	1
31	5	...	...	289	...	...	...
31	5	...	297	289.7	...	...	1
33	5	...	...	...	...	...	...
33	13	...	309	312	285	-333	...
33	5	...	324.3	...	307	-361	11.4
34	5	...	...	...	...	...	...
35	5	...	...	...	...	...	...
36	5	...	...	...	...	...	...
36	5	...	337	...	...	...	1
37	5	...	...	...	...	...	...
38	5	...	...	...	...	...	...
38	5	...	...	...	...	...	...
39	5	...	...	...	...	...	...
39	5	...	151	...	...	...	...
40	5	...	...	...	...	...	...
41	5	...	...	...	...	...	...
41	5	...	161	573	...	...	20.2
41	5	...	...	...	...	...	1
42	5	...	...	...	...	...	...
42	5	...	...	...	...	...	...
42	5	...	...	...	...	...	...
HERRING.							
1.86	4	0.0131	...	...	...	...	...
2.91	11	0.0582	...	...	...	...	14
4.3	11	.32	...	...	.31-	.34	.01
4.8	11	.42	...	...	.38-	.47	...
5.0	31	...	...	...	2.7-	3.2	.1
5	...	...	3.63	...	3.5-	4.0	...
9	7	4.1	4.27	3.4-	4.9	...	8
5	...	4.9	4.97	4.4-	5.5	...	11
10	11	5.9	5.90	5.3-	7.1	.2	5

SPRAT.

Length.		Weight in Grammes.			Average Weight in Ounces.	No. of Fish.
In Cm.	In Inches.	Average.	Smoothed Average.	Range.		
4	1 ² / ₁₆	...	...	...	...	...
.5	1 ³ / ₄	.50	...	...	...	1
5	2	.67	.67	.63— .75	.02	8
.5	...	.84	.88	.7 — 1.0	...	28
6	¹ / ₂	1.14	1.17	.92— 1.3	.04	20
.5	...	1.53	1.57	1.1 — 2	...	15
7	³ / ₄	2.04	2.02	1.6 — 2.3	.07	21
.5	...	2.48	2.59	2.0 — 2.8	...	33
8	3 ¹ / ₈	2.90	3.05	2.4 — 3.6	...	33
.5	...	3.76	3.72	3.3 — 4.3	...	14
9	¹ / ₂	4.59	4.63	3.8 — 5.3	...	11
.5	...	5.53	5.56	4.9 — 6.5	...	14
10	1 ¹ / ₂	6.55	6.76	5.5 — 8	.23	12
.5	...	8.2	8.08	7.1 — 9.2	...	20
11	4 ⁵ / ₁₆	9.5	9.48	7.8 —11.8	...	27
.5	...	10.75	10.86	9.7 —12.9	...	28
12	³ / ₄	12.34	12.46	10.8 —14.2	.4	33
.5	...	14.27	14.34	12.2 —15.4	...	15
13	5 ¹ / ₄	16.4	...	...	...	1

LUMPENUS.

15	5 ¹ / ₄	...	...	...	...	...
.5	...	4.4	...	...	.15	1
16	6 ¹ / ₈	...	...	...	...	...
.5	...	5.0	..	...	...	1
17	1 ¹ / ₂	5.17	5.32	4.2 — 6	...	3
.5	...	5.8	5.91	...	...	1
18	7 ¹ / ₄	...	6.41	...	...	...
.5	...	7.17	6.86	...	...	3
19	¹ / ₂	7.25	7.5	7.2 — 7.3	...	2
.5	...	8.1	7.65	7.4 — 8.7	...	3
20	¹ / ₂	7.6	8.07	7.5 — 7.6	.27	2
.5	...	8.5	8.7	...	...	1
21	8 ¹ / ₄	...	9.38	...	...	...
.5	...	9.9	10.09	8.8 — 10.7	...	6
22	1 ¹ / ₂	10.45	10.68	10.4 — 10.5	...	2
.5	...	11.7	11.45	10.4 — 13.1	...	2
23	9 ¹ / ₄	12.2	12.45	10.3 — 14.7	...	5
.5	...	13.4	12.93	12.3 — 13.8	...	4
24	⁷ / ₁₆	13.2	13.77	12.8 — 13.7	...	2
.5	...	14.7	...	13.8 — 15.6	.52	2
25	⁷ / ₈	...	...	...	...	...

LUMPENUS—continued.

Length.		Weight in Grammes.			Average Weight in Ounces.	No. of Fish.
In Cm	In Inches.	Average.	Smoothed Average.	Range.		
26	10½	18·2	...	...	...	1
27	11	...	...	...	...	...
28	11	20·2	...	18 - 22·4	71	2
29	11½	...	...	...	...	...
30	12	...	...	...	...	...

POGGE.

5	...	...	...	...	...	...
6	...	...	...	...	...	...
7	...	...	...	...	...	...
8	3½	3·72	...	3·42- 3·93	13	6
9	4	4·5	4·47	3·93- 4·94	...	12
10	4½	5·2	5·46	4·45- 5·83	...	12
11	4½	6·48	6·34	5·15- 6·85	...	14
12	5	7·34	7·36	6·88- 7·66	26	3
13	5½	8·25	8·74	7·87- 8·64	...	2
14	6	10·62	10·55	...	...	1
15	6½	12·77	12·30	...	...	1
16	7	13·52	13·80	12·71-14·63	48	4
17	7½	15·12	15·38	15 - 15·25	...	2
18	8	...	17·51	...	...	...
19	8½	21·27	19·64	...	75	1
20	9	20·13	...	...	...	1
21	9½	...	...	...	...	...
22	10	...	...	...	...	...

PLAICE.

SHOWING THE CALCULATED WEIGHT AT VARIOUS SIZES.

Length in Centimetres.	Weight in Grammes.	Length in Centimetres.	Weight in Grammes.
1	·009	36	435·632
2	·075	37	472·947
3	·252	38	512·336
4	·598	39	553·861
5	1·167	40	597·500
6	2·017	41	643·515
7	3·252	42	702·346
8	4·78	43	742·357
9	6·807	44	795·360
10	9·338	45	850·838
11	12·428	46	908·824
12	16·134	47	969·398
13	20·513	48	1032·600
14	26·013	49	1115·295
15	31·509	50	1167·200
16	38·240	51	1238·436
17	45·868	52	1312·856
18	54·454	53	1390·065
19	64·042	54	1470·249
20	74·700	55	1553·443
21	87·793	56	1648·160
22	99·420	57	1729·147
23	113·603	58	1821·760
24	129·075	59	1917·624
25	145·900	60	2016·792
26	164·107	61	2119·322
27	183·781	62	2225·269
28	208·102	63	2370·411
29	227·720	64	2447·360
30	252·072	65	2564·174
31	278·159	66	2684·344
32	305·920	67	2808·225
33	335·543	68	2935·552
34	366·944	69	3068·281
35	406·450	70	3251·592



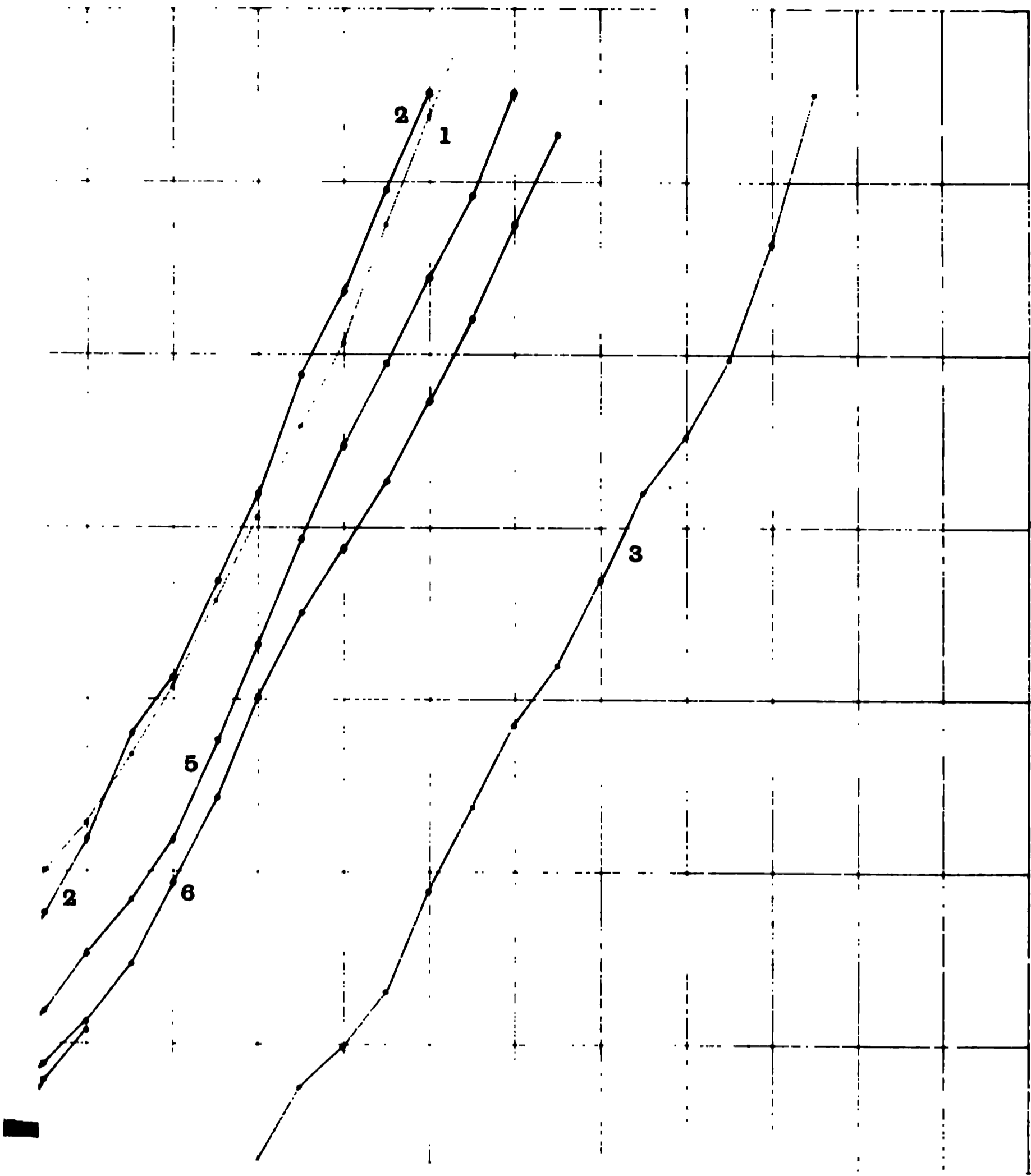
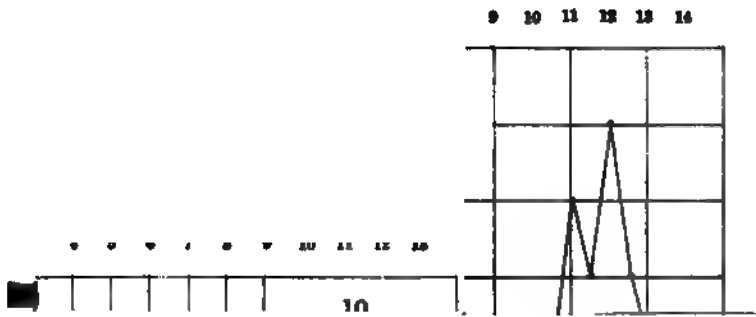


PLATE VIII.



OF
MICH.

1.

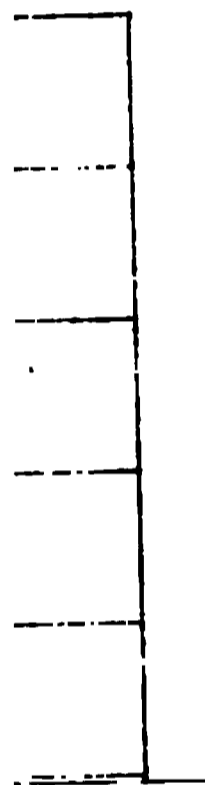
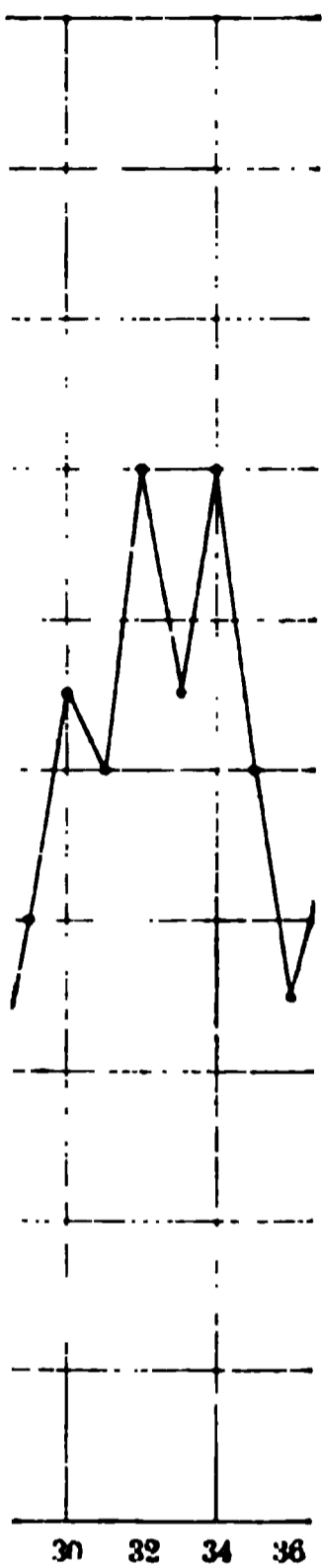
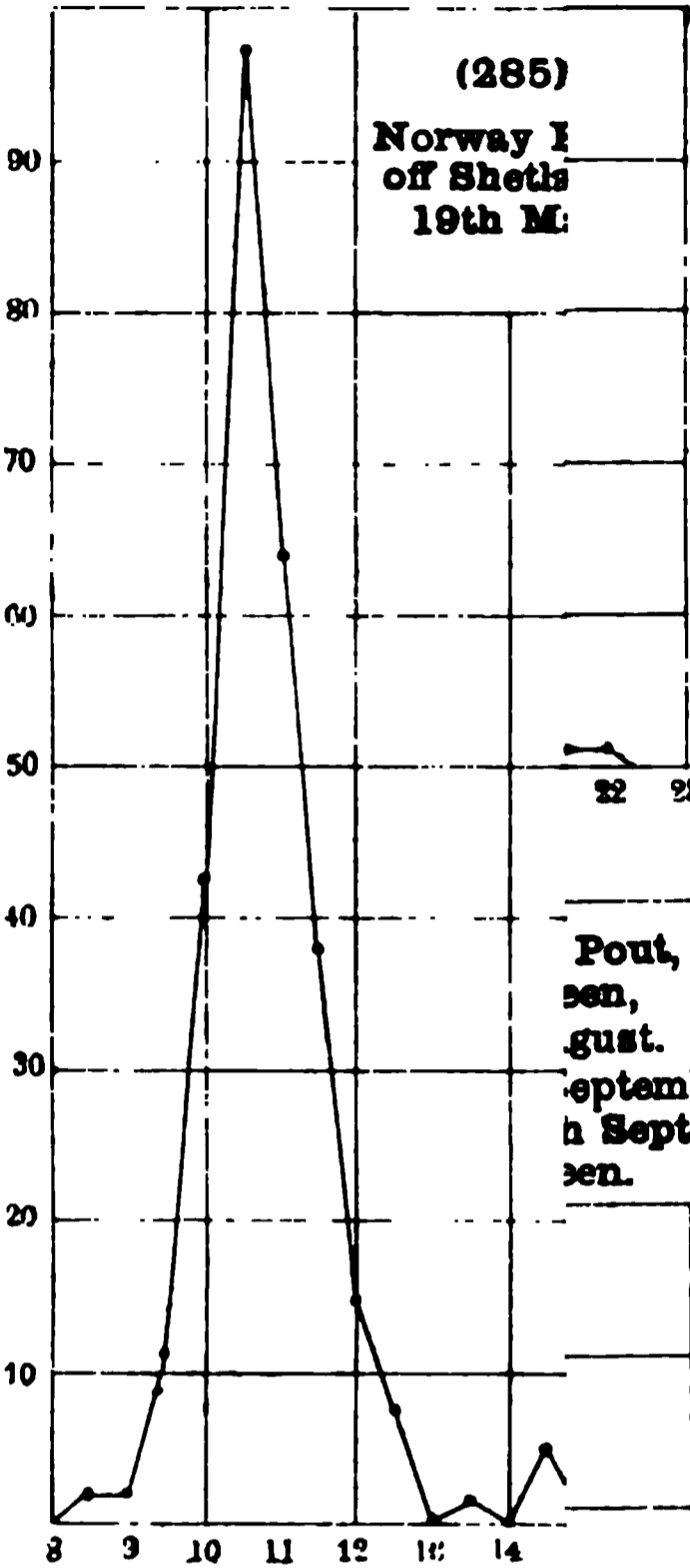
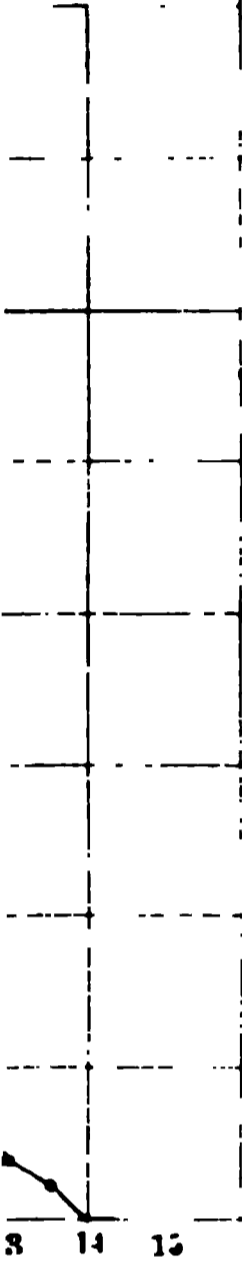
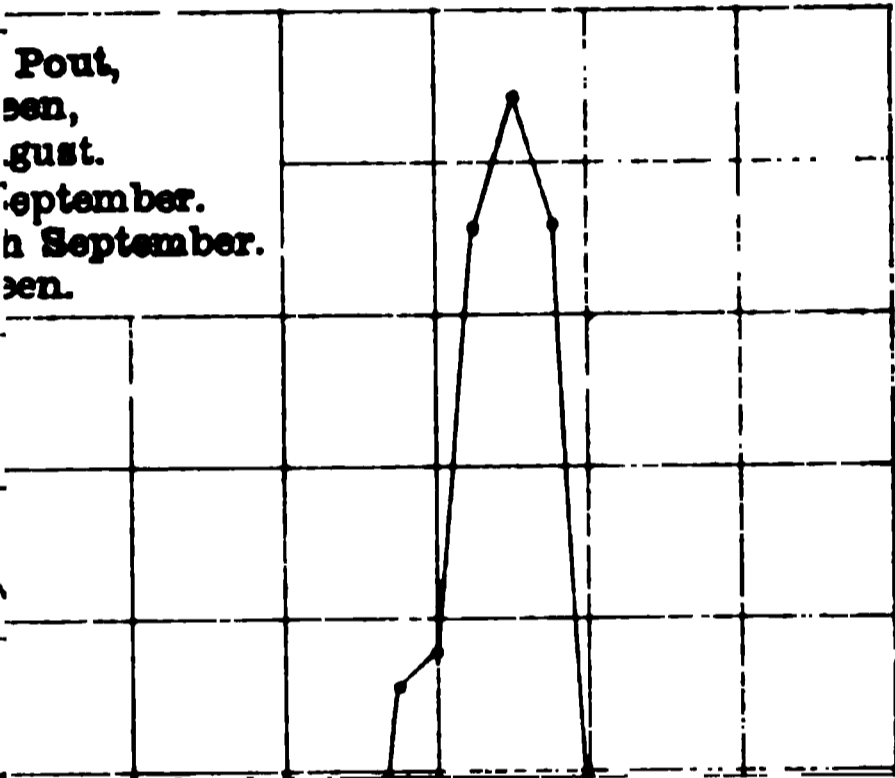


PLATE XII.

rway Pout.
Burghead,
st April.



Pout,
sen,
gust.
eptember.
h September.
sen.



. HADDOCK.

SHOWING THE CALCULATED WEIGHT AT VARIOUS SIZES.

Length in Centimetres.	Weight in Grammes.	Length in Centimetres.	Weight in Grammes.
1	·008	36	367·200
2	·063	37	398·639
3	·213	38	431·846
4	·504	39	467·023
5	·984	40	503·733
6	1·700	41	542·408
7	2·700	42	583·073
8	4·030	43	625·720
9	5·738	44	670·449
10	7·870	45	717·188
11	10·476	46	766·034
12	13·600	47	817·087
13	17·297	48	870·400
14	22·566	49	914·465
15	26·563	50	983·800
16	32·239	51	1043·963
17	38·665	52	1107·018
18	45·900	53	1171·662
19	53·980	54	1239·300
20	62·967	55	1309·470
21	72·884	56	1444·332
22	83·806	57	1457·468
23	95·754	58	1535·531
24	108·800	59	1616·333
25	122·974	60	1700·000
26	138·377	61	1786·340
27	154·913	62	1875·641
28	180·529	63	1967·870
29	191·941	64	2063·290
30	212·500	65	2162·144
31	234·455	66	2262·764
32	257·911	67	2367·005
33	282·846	68	2474·580
34	309·322	69	2585·366
35	337·440	70	2699·524

IV.—NOTES ON SOME RARE AND INTERESTING MARINE CRUSTACEA.

By THOMAS SCOTT, LL.D., F.L.S.

(Plates XIII–XV)

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PRELIMINARY REMARKS.

In the following notes I have described a number of minute Crustaceans belonging to the Monstrillidæ and the Choniostomatidæ—two families of Copepoda containing aberrant and parasitic forms of more than usual interest. A few forms belonging to other groups more or less rare in the Scottish seas are also recorded here.

The species recorded here belonging to the Monstrillidæ are as follows:—

- Monstrilla grandis*, Giesbrecht.
- „ *longicornis*, I. C. Thompson.
- „ *gracilicauda*, Giesbrecht.
- „ *anglica*, Lubbock.
- „ *dubia*, T. Scott, sp. n.
- Thaumaleus thompsoni*, Giesbrecht.
- „ *rigidus* (I. C. Thompson).
- „ *zetlandicus*, T. Scott, sp. n.
- „ *rostratus*, T. Scott, sp. n.

The following are the names of the seven species belonging to the Choniostomatidæ which are also described :—

- Stenothocheres egregius*, Hansen, new to British Fauna.
- Sphaeronella paradoxa*, Hansen, „ „ „
- „ *minuta*, T. Scott, sp. n.
- „ *callisomæ*, T. Scott, sp. n.
- „ *cluthæ*, T. Scott, sp. n.
- „ *pygmæa*, T. Scott, sp. n.
- „ *amphilochi*, Hansen.

A description is furnished of each of the species mentioned above, and this is illustrated by drawings which have been prepared by my son, Mr. A. Scott, A.L.S., who also prepared most of the dissections required. The preparing of these dissections was in some cases rendered more difficult when the species happened to be represented by only a single

specimen whose appendages were not very obvious even with a moderately high magnification.

Some moderately rare species of Amphipoda and Sympoda are recorded at the end of the paper, the names of which are as follows :—

Hyperia medusarum (O. F. Muller).
Tryphana malmi, Boeck.
Anonyx nugax (Phipps).
Hoplonyx cicada (Fabr.).
Harpinia pectinata, G. O. Sars.
Metopa borealis, G. O. Sars.
Paratylus falcatus (Metzger).
Megaluropus agilis, Norman
Idothea neglecta, G. O. Sars.
Eudorellopsis deformis, Kryöer.
Pseudocuma similis, G. O. Sars.

The following are the descriptions of the various species referred to :—

COPEPODA.

Fam. MONSTRILLIDÆ

Genus *Monstrilla*, Dana, 1848.

Monstrilla grandis, Giesbrecht. Pl. xiii., fig. 11, 12; pl. xiv., fig. 9–11; pl. xv., fig. 1, 2.

1892. *Monstrilla grandis*, Giesb., Pelag. Copep. des Golfes v. Neapel, p. 588, pl. 46, fig. 2, 8, 11, 17, 19, 24, 25, 35, 39.

Description of the Female :—In this species the antennules of the female, which are moderately stout, are scarcely equal to one-fourth the length of the animal; their structure is somewhat similar to that of the antennules of *M. gracilicauda*, but the articulations are rather more distinct (fig. 9, pl. xiv.).

The fifth pair of thoracic feet are sub-cylindrical, about twice as long as broad, and with a somewhat bi-lobed extremity (fig. 10, pl. xiv.); the exterior lobe bears three setæ, the inner one is small but the other two are elongated. The inner lobe appears to be furnished with only a single apical seta, but our dissection shows what appears to be the base of a seta on the inner margin of this lobe, the seta itself having probably been broken off; the position of this seta is indicated on the drawing by dotted lines.

The abdomen consists of three segments, but the first, which is larger than the next two combined, is divided into two portions by a pseudo-articulation as shown by the drawing (fig. 11, pl. xiii., and fig. 11, pl. xiv.); the second and third segments are sub-equal and are together much smaller than the first segment.

The furcal joints are each provided with six setæ, one being situated on the outer edge near the base of the joint while the others spring from the apex (fig. 11, pl. xiv.); one of the apical setæ near the inner edge is very small.

The female represented by the drawing (fig. 11, pl. xiii.) measures 4·25 mm. (about $\frac{1}{8}$ of an inch).

Description of the Male :—The male is much smaller than the female; the specimen represented by the drawing (fig. 12, pl. xiii.) measures only 2 mm. ($\frac{2}{5}$ of an inch).

The antennules of the male, which are proportionally rather longer than those of the female, are five-jointed, the last joint being hinged to the preceding one (fig. 1, pl. xv.).

The first and second segments of the male abdomen are not coalescent as in the female, but otherwise the two sexes are nearly alike.

The armature of the furcal joints (fig. 2, pl. xv.) is similar to that of the female.

The fifth pair of feet resemble very closely the fifth pair of the male of *M. longiremis*.

Habitat.—Head of Loch Fyne (Firth of Clyde), November 28, 1899, one female, and January 30, 1901, a male and a female.

Professor G. S. Brady records a *Monstrilla*, obtained at Cullercoats in July, 1900, which he thinks may be the male of *M. grandis*, Giesbrecht,* and I. C. Thompson mentions the occurrence of the same species in the vicinity of the Channel Islands.†

Monstrilla longicornis, I. C. Thompson. Pl. xiii., fig. 1–7.

1890. *Monstrilla longicornis*, I. C. Thompson, Trans. L'pool. Biol. Soc., vol. iv., p. 119, pl. iv., figs. 1, 2, and 4 (♂).

1892. *Monstrilla longiremis*, Giesb., Pelagischen Copepoden des Golfes von Neapel, p. 589, pl. 46, figs. 10, 14, 22, 37, and 41 (♀).

1902. *Monstrilla longiremis*, T. Scott, 20th Rept. Fishery Board for Scotland, pt. iii., p. 469, pl. xxv., figs. 3 and 4 (♀).

The antennules in both the female and male are elongated and slender, being in some examples nearly half as long as the cephalothorax and abdomen combined; but their length seems to vary to some extent in different individuals, and those of the male appear to be proportionally rather longer than in the female. The male antennules are composed of six joints, and the articulation between the fifth and sixth is so hinged that the sixth joint can be folded inwards; the second and last joints are of nearly equal length and considerably longer than any of the others (fig. 6). In the female antennules all the joints except the first appear to be coalescent, so that each antennule is apparently only two-jointed (fig. 3).

The fifth thoracic feet of the female consist each of a sub-cylindrical plate, but the proximal half of the leg is rather wider than the lower half and is defined from it by a distinct notch on the inner margin, and from this notch there springs a moderately long seta; three other setæ spring from the distal extremity of the leg, but the innermost one is short while the other two are elongated; all the setæ appear to be more or less plumose (fig. 4).

The fifth feet of the male are somewhat rudimentary, each being represented by a single moderately long plumose seta which springs from a small tubercle near the lower ventral margin of the last thoracic segment. The genital appendages are narrow and spiniform (fig. 7).

The furcal joints in the female are each furnished with five moderately long setæ, but there are only four setæ to each of the furcal joints in the male. This appears to be the only British species of *Monstrilla* in which the number of furcal setæ in the female is five.

The male of *Monstrilla longicornis* does not appear to have been previously recorded except by I. C. Thompson.

* Nat. Hist. Trans. Northumb., Durham, and Newcastle, vol. xiv., p. 64, pl. iv., fig. 1–3.

† Journ. Marine Zool. and Microscopy, vol. ii., p. 97 (No. 8, December, 1897).

The following are the localities whence I have obtained this species and the dates when the different specimens were collected:—

- Firth of Forth, between Fidra and the Bass Rock, October 18, 1890 (♀).
- Firth of Forth, east of Inchkeith, August 14, 1891 (♀ & ♂).
- Firth of Forth (locality not stated), 1893 (♀ & ♂).
- Firth of Forth, Station V. (to the west of May Island), August 30, 1894 (♀ & ♂).
- Firth of Forth, Station V., July 24, 1901 (♀).
- Firth of Tay, at Buddon, December 5, 1902 (♀).
- Thirty-five miles east of May Island (per s.s. "Glenogle," of Aberdeen), August 20, 1903 (♀ & ♂).
- Off Aberdeen about ten miles, November 11, 1901 (♀).
- Firth of Clyde, off the Ayrshire coast, November (date not stated), 1895 (♀).
- Firth of Clyde, head of Loch Fyne, December 11, 1897 (♀).
- Firth of Clyde, Whitefarland Bay, Arran, July 6, 1899 (♂).
- Solway Firth, Luce Bay (per Andrew Scott), November 26, 1901 (♀).
- Larne Harbour, Ireland (per Andrew Scott), January 14, 1904.

The female represented by the drawing (fig. 1) measured 3.1 mm., which is similar to the size given by Dr. Giesbrecht; the length of the male which the drawing represents (fig. 2) is 2 mm.

One or two of the more obvious characters by which *M. longicornis* may be distinguished from other forms are the long and somewhat slender antennules, the form and armature of the fifth pair of thoracic feet, and the number of the furcal setæ. The structure of the abdomen appears also to differ to some extent from the other species of *Monstrilla* recorded here.

It may be remarked further that the integument in this species when examined with the microscope and under a moderately high power is seen to have a granular appearance not observed in other species (see the drawings, figs. 1 and 2).

That I. C. Thompson's *Monstrilla longicornis* is identical with *M. longiremis*, Giesbrecht, must, I think, be admitted. The long antennules, the granular appearance of the integument, the number of furcal setæ, and the structure of the abdomen show that it can be nothing else, and as Thompson's name was published two years before that of Dr. Giesbrecht it must be restored. Thompson does not appear to have seen the female or Dr. Giesbrecht the male of this species.

Monstrilla gracilicauda, Giesbrecht. Pl. xiii., fig. 8–10; pl. xiv., fig. 15.

1892. *Monstrilla gracilicauda*, Giesb., op. cit., p. 587, pl. 46, figs. 9, 16, 18, 29, 32, 43.

In the female of *Monstrilla gracilicauda* the antennules are rather shorter than in the species just described. They appear to be four-jointed, the first three being small, while the end joint is equal to the entire length of the other three (fig. 8, pl. xiii.).

The fifth pair of thoracic feet (fig. 15, pl. xiv.) are sub-quadrate in outline, rather longer than broad, and somewhat gibbous at the distal end as shown in the drawing; each foot is furnished with three plumose setæ, one on the outer aspect and two at the apex, the feathering is very delicate and can only be seen by using a moderately high magnification.

The abdomen consists of four segments, the first segment, which

appears to consist of two coalescent segments, is of a sub-cylindrical form but tapers slightly towards the distal extremity; it is about one-third longer than the breadth at the widest part and nearly twice the entire length of the next segments. The third segment is only about half the length of the second one.

The furcal joints are each provided with six setæ arranged as shown in the drawing (fig. 10, pl. xiii.), but one of the setæ is very small.

The length of the specimen represented by the drawing is 3.1 mm., which is somewhat larger than that stated by Dr. Giesbrecht. No males of this species have been observed hitherto.

M. gracilicauda has been collected at the following places:—

Firth of Forth, above Queensferry, June 26, 1890 (♀).

Firth of Forth, off Musselburgh, September 29, 1892 (♀).

*35 miles east of May Island, Firth of Forth (per s.s. "Glenogle"), August 20, 1903 (♀).

Firth of Clyde, Whitefarland Bay, Arran, July 6, 1899 (♀).

Firth of Clyde, near head of Loch Fyne, November 28, 1899 (♀).

Monstrilla anglica, Lubbock. Pl. xiii., fig. 13; pl. xiv., fig. 12–14.

1857. *Monstrilla anglica*, Lubbock. Ann. and Mag. Nat. Hist. (2), vol. xx., p. 409, pl. x., fig. 7, 8.

1900. *Monstrilla* (?) *danæ*, Scott, 18th Ann. Rept. Fishery Board for Scotland, pt. iii., p. 398, pl. xiii., fig. 15–20.

Description of the Female.—The specimen represented by the drawing measures 3.2 mm. (nearly $\frac{1}{8}$ of an inch); it has a general resemblance in size and structure to *Monstrilla longicornis*, but is scarcely so robust (fig. 13, pl. xiii.).

The antennules are elongated and slender and indistinctly three-jointed; the basal joint is as usual very short; the next, which is not very clearly defined, is also small, but longer than the basal joint; the remaining portion consists of a single piece which may be made up of two or three coalescent joints (fig. 12, pl. xiv.).

The fifth pair of thoracic feet are sub-cylindrical in outline, and nearly twice as long as broad; each foot is furnished with two elongated apical setæ, and the inner margin, which is nearly straight and shorter than the outer margin, terminates in a small rounded process, beyond which the distal portion of the foot becomes narrower as shown in the drawing (fig. 13, pl. xiv.).

The genital filaments are scarcely equal in length to the furcal setæ.

The abdomen appears to consist of three segments; the first segment is about twice the length of the second, while the second is about one and a half times the length of the third.

The furcal joints are each furnished with six setæ (fig. 14, pl. xiv.).

Habitat.—Firth of Forth, west of May Island, July 26, 1901; thirty-five miles east of May Island, August 20, 1903, per s.s. "Glenogle." Females only were observed in both gatherings.

This species resembles *M. longicornis* in size, in the elongate antennules, and to some extent in the structure of the abdomen, but differs very distinctly in the armature of the fifth pair of thoracic feet, and in possessing six instead of five furcal setæ; and the integument appears to want the minutely granulated structure observed in *M. longicornis*.

The specimens recorded by me in Part III. of the Eighteenth Annual Report of the Fishery Board for Scotland from the Firth of Clyde appear to belong to Lubbock's *Monstrilla anglica*; these specimens were

* This specimen was of a fine green colour.

apparently imperfect as regards the furcal hairs, and no doubt helped to disguise their relationship with the species named. Having now obtained specimens in fairly good condition, I am enabled to give a few accurate figures of the female which may be of interest as supplementing Dr. Bourne's very fine drawings of the male. (See the Quarterly Journ. of Micros. Science, vol. xxx., pt. 4, new series, Feb. 1890.)

Monstrilla dubia, T. Scott, sp. n. Pl. xiii., fig. 14; pl. xiv., fig. 16-18.

Description of the Female.—Body moderately slender; length of the specimen represented by the drawing is 3.3 mm. (fully $\frac{1}{8}$ of an inch). The cephalothoracic segment is about one and a half times the entire length of the remaining thoracic segments and abdomen.

The abdomen is composed of three segments; the first segment is about equal in size to the last segment of the thorax, the second is smaller than the next, while the second and third are together scarcely as long as the first segment (fig. 14, pl. xiv.).

The antennules are moderately stout and about half as long as the cephalothoracic segment, and composed of four joints; the first and third joints are small, the second is about half as long again as the third, while the fourth is equal to the entire length of the three joints (fig. 16, pl. xiv.).

The fifth pair of thoracic feet are moderately slender; each foot is narrow and sub-cylindrical at the proximal end, but becomes wider distally and terminates in two lobes; the outer lobe is larger than the inner and is furnished with three moderately long setæ, the inner lobe is narrow and appears to be devoid of setæ as shown in the drawing (fig. 17, pl. xiv.).

The furcal joints are each provided with four elongated hairs, one of them springs from near the base of the outer margin, two spring from the apex, while the fourth is attached on the inner aspect and near the middle of the joint, as seen in the drawing (fig. 18, pl. xiv.).

Habitat.—Firth of Forth, east of Inchkeith, August 14, 1891; and head of Loch Fyne (Firth of Clyde), November 11, 1897, and November 28, 1899. No males have been observed.

Remarks.—The Copepod of which I have just given a description does not agree with any described species known to me. The characters by which it may be distinguished are the following three: first, the structure of the abdomen, the first segment of which is as large as the segment of the thorax next to it; second, the peculiar form of the fifth pair of thoracic feet; and, third, the number and arrangement of the furcal setæ.

Monstrilla dubia as described and figured here has a somewhat close resemblance to the female of *M. danæ* as represented by the beautiful drawings of Professor Claparède,* and especially by figure 3, taf. xvi., which shows the female from the under side; the proportional lengths of the abdominal and of the posterior thoracic segments are almost identical, but the furcal joints are represented with only three setæ; there is also a slight difference in the length of the second joint of the antennules. Had a separate drawing of the fifth pair of thoracic feet of the female been given by that author the identification of the species would have been rendered more certain.

* Beobachtungen über Anatomie und Entwicklungsgeschichte wirbelloser thier an der küste von Normandie, Angestellt, p. 95, taf. xvi., fig. 1-6 (1863).

Genus *Thaumaleus* Kröyer, 1849.

Thaumaleus thomsoni, Giesb. Pl. xiv., fig. 1-4.

1892. *Thaumaleus thomsoni*, Giesb., Pelag. Copep. des Golfes v. Neapel, p. 584, pl. 46, fig. 7, 27, 31, 36, 40.

1902. *Thaumaleus thompsoni*, Scott, 20th Ann. Rept. Fishery Board for Scotland, pt. iii., p. 470, pl. xxv., fig. 5, 6.

In Part III. of the Twentieth Annual Report of the Fishery Board for Scotland, I published a description with figures of the male of *Thaumaleus thompsoni* taken in Lerwick Harbour, Shetland. Recently, when examining a small collection of *Monstrillas* that had been captured from time to time during the past twelve or fifteen years, I found a single female of the same species that had been taken in a tow-net sample collected off Scarborough on July 9, 1893, during some investigations on behalf of the Fishery Board for Scotland; this specimen I will now briefly describe, and illustrate the description with figures showing a few of its more characteristic features.

The specimen referred to was elongated and very slender, and measured 4.8 mm. in length (about $\frac{1}{5}$ of an inch). The cephalothoracic segment was about equal to twice the entire length of the remaining segments of the thorax and abdomen combined (fig. 1, pl. xiv.).

The antennules are short and stout, and appear to consist of four joints; but the third, which is small, seems to be partly coalescent with the second (fig. 2, pl. xiv.).

The fifth pair of thoracic feet are moderately large, foliaceous, and are abruptly wider at the distal extremity, the result of a lobe-like process on the inner distal aspect; each foot carries three apical setæ, the innermost of which is considerably shorter than the other two, as shown in the drawing (fig. 3, pl. xiv.).

The abdomen consists of two segments; the first is fully half as long as the last segment of the thorax, and larger and more dilated than the second segment. The short furcal joints carry three moderately elongated setæ (fig. 4, pl. xiv.).

The structure of the fifth pair of thoracic feet, and the form of the abdomen referred to above, seem to be characteristic of this species.

Thaumaleus rigidus (I. C. Thompson). Pl. xiii., fig. 15-17; pl. xiv, fig. 19.

1888. *Cymbasoma rigida*, I. C. Thompson. Linn. Soc. Journ. Zool., vol. xx., p. 154, pl. xiii., fig. 1-4.

1890. *Monstrilla rigida*, Bourne. Quart. Journ. Micros. Science, vol. xxx., pl. xxxvii., fig. 8, 11, 12.

1892. *Thaumaleus claparèdii*, Giesb., op. cit., pp. 381-385, taf. 46, fig. 5, 15, 21, 26.

Description of the Female.—Length of the specimen represented by the drawing (fig. 15, pl. xiii.), 2.7 mm. ($\frac{1}{8}$ of an inch). The cephalothorax is moderately stout, rather wider near the anterior end, and nearly twice as long as the entire length of the remaining segments. The abdomen is composed of two segments; the first is about one and a half times the length of the last segment of the thorax, and the proximal half is more or less dilated; the second segment, which is smaller than the first, is probably composed of two coalescent segments, as a slight constriction, dividing the segment into two portions as shown by the drawing (fig. 15, pl. xiii., and fig. 19, pl. xiv.), is observable in all the specimens examined.

The antennules are short and stout and appear to be four-jointed, the first and third joints being very small (fig. 16, pl. xiii.).

The fifth pair of thoracic feet are rather longer than broad, the terminal portion being distinctly small and wider than the proximal half; each foot carries three moderately long apical setæ, as shown in the drawing (fig. 17, pl. xiii.).

The furcal joints, which are of moderate length, are each furnished with three setæ (fig. 19, pl. xiv.).

Habitat.—Mauchrie Bay, Arran, Firth of Clyde, September 17, 1886. St. Andrews Bay, August 7, and off St. Monans, Firth of Forth, September 6, 1890. Dornoch Firth (Moray Firth district), July 30, 1895. Whitefarland Bay, Arran, Firth of Clyde, July 6, and between Arran and the Ayrshire coast, November 9, 1899. All the specimens obtained were females.

Remarks.—I have adopted I. C. Thompson's name for this form in preference to that of Dr. Giesbrecht, as I am convinced, after examining a number of individuals and comparing them with the descriptions and figures of Thompson and Bourne, that *Thaumaleus rigidus* (I. C. Thompson) and *T. claparèdii* are identical. The antennules of the female in both are short and stout, and although Thompson's figure indicates a greater number of articulations than is observed in *T. claparèdii*, this may be due perhaps to certain constrictions having been mistaken for joints; but what I rely on chiefly is the structure of the abdomen and the form and armature of the fifth pair of thoracic legs of the female, which, so far as they are represented by both Thompson's and Bourne's figures, are practically the same as the similar parts of *T. claparèdii* represented by the drawings of Dr. Giesbrecht.

Thaumaleus zetlandicus, T. Scott, sp. n. Pl. xiii., fig. 18, 19; pl. xiv., fig. 20–22; pl. xv., fig. 3, 4.

Description of the Female.—Body moderately stout and elongated; length of the specimen represented by the drawing (fig. 18, pl. ii.), 4·8 mm. (nearly $\frac{1}{5}$ of an inch). The cephalothoracic segment is about one and a half times the entire length of the remaining segments of the thorax and abdomen.

The abdomen is composed of three segments; the first segment is distinctly larger than the last segment of the thorax and about twice the entire length of the next two abdominal segments; these two segments are sub-equal, but the second is slightly the longer of the two (fig. 22, pl. xiv.).

The antennules, which are short and moderately stout, are composed of four joints; the first and third joints are smaller than the others, while the end joint is about equal to the entire length of the other three (fig. 20, pl. xiv.).

The fifth pair of thoracic feet are short and broadly foliaceous and terminate in two broad rounded sub-equal lobes, the outer one of which is provided with three moderately long setæ; the inner lobes do not appear to carry any setæ (fig. 21, pl. xiv.).

A male belonging apparently to the same species as the female described above is considerably smaller than it, and the cephalothoracic segment is only slightly longer than the combined lengths of the other thoracic segments (fig. 19, pl. xiii.). The length of this male, which is represented by the drawing just referred to, is 2·6 mm. (or nearly $\frac{1}{10}$ of an inch). The antennules are five-jointed and longer than those of the female (fig. 3, pl. xv.); the abdomen appears to consist of four segments, the first two are sub-equal and are each distinctly smaller than the last segment of the thorax, while the last two are together only a little longer than the preceding segment. The number of furcal hairs is the same as in the female (fig. 2, pl. xv.).

Habitat.—Lerwick Harbour, Shetland, October 15, 1901.

Remarks.—The more obvious characters by which this species may be distinguished are: the structure and lengths of the female antennules, the three-segmented abdomen, together with the proportional difference in the size of the first segment with the preceding segment of the thorax and the other two abdominal segments; and lastly, the peculiar form of the fifth pair of thoracic feet, as indicated by the various figures.

Thaumaleus rostratus, T. Scott, sp. n. Pl. xiv., fig. 5–8.

Description of the Female.—The length of the specimen represented by the drawing (fig. 5) is 3.9 mm. (about $\frac{2}{13}$ of an inch); the first cephalothoracic segment is moderately stout, tapering gradually in front into a blunt pointed rostrum; while posteriorly the body becomes gradually narrower towards the distal extremity (fig. 5, pl. xiv.).

The abdomen is composed of three segments; the first segment is as large as the next two together, but the second is very small.

Each of the furcal joints is provided with three setæ of moderate lengths, arranged as shown in the drawing (fig. 8, pl. xiv.).

Antennules short and moderately stout, four-jointed and sparingly setiferous; the first and third joints are small, the second is about one and a half times the length of the third, while the last is equal to the entire length of the other three joints (fig. 6, pl. xiv.).

The fifth pair of thoracic feet are short and foliaceous, and each terminates in two unequal lobes; the outer lobe, which is narrower than the inner and projects somewhat beyond it, is furnished with three moderately long setæ; the inner lobe is broadly rounded and provided with a single seta (fig. 7, pl. xiv.).

Habitat.—Lerwick Harbour, Shetland, October 15, 1901. Three or four specimens were obtained, all of which were females.

Remarks.—The form just described is readily distinguished by the produced forehead and by the form and armature of the fifth pair of thoracic feet.

Fam. CHONIOSTOMATIDÆ, Hansen (1887).

Genus *Stenothocheres*, Hansen (1897).

Stenothocheres egregius, H. J. Hansen. Pl. xv., fig. 5–10.

1897. *Stenothocheres egregius*, Hansen, The Choniostomatidæ, p. 89, pl. i., fig. 1 a-e.

The *Spheronella*-like form which I ascribe to *Stenothocheres egregius* was obtained in the marsupium of *Metopa borealis*, G. O. Sars. The female represented by the drawing (fig. 5) measured about .68 mm. in length (nearly $\frac{1}{37}$ of an inch); the body was almost spherical in shape, but was rather longer than the height.

The antennules are small (fig. 7), and the end joint, which is furnished with two moderately long spine-like terminal setæ, is about one and a half times as long as the preceding one.

The antennæ are very minute and composed of two sub-equal joints, and they are each armed with a comparatively stout terminal spine (fig. 8).

The maxillipeds were damaged while being removed for the purpose of mounting, but the second pair, so far as they could be made out, appear to be moderately strong with stout terminal claws as indicated in figure 6.

The first pair of feet, though very small, are comparatively stout and two-branched, and both branches appear to be two-jointed; the inner branches are furnished with three apical spines, the middle one being

moderately elongated, while the other two are short; the outer branches, on the other hand, are provided with one terminal spine which is moderately stout (fig. 9).

The second pair appear to be more slender than the first, and the inner branches are only one-jointed and bear a single moderately long apical spine; the outer branches, which are two-jointed, are only armed with a very short spine at the apex (fig. 10).

The abdomen is very small and provided with two furcal joints which bear a few minute setæ.

The Amphipod on which the parasite was observed occurred in a surface tow-net gathering collected in Aberdeen Bay on October 16, 1903. The parasite agrees very closely with the description and drawings of *S. egregius*, Hansen, as given in that author's Monograph of the Choniostomatidæ referred to above, and therefore, though the Amphipod on which it was found (*Metopa borealis*, G. O. Sars) is a different species from that mentioned by Dr. Hansen as the host *S. egregius*, I am satisfied that the parasite I have described belongs to that species.

The Amphipod on which Dr. Hansen obtained his specimens of *S. egregius* belonged to *Metopa bruzelii* (Goës.).

Sphaeronella paradoxa, H. J. Hansen. Pl. xv., fig. 17-19.

1897. *Sphaeronella paradoxa*, Hansen, The Choniostomatidæ, p. 118, pl. iii., fig. 4 a-l; pl. iv., fig. 1 a-h.

The female of this *Sphaeronella* represented by the drawing (figs. 16 and 17) is smaller than those described by Dr. Hansen, being only .57 mm., whereas the smallest of the specimens mentioned by that author was .71 mm. But with the exception of the difference in size the specimen recorded here agrees very well with the species to which it is referred. The specimen was found in the marsupium of *Bathyporeia pelagica* (Bate). The figure representing a side view of the parasite shows the posterior thread-like attachment considerably twisted upon itself and terminating in a sucker disc; the only other appendages visible are at the anterior end, and comprise a pair of antennules and a pair of powerful maxillipeds.

Six specimens of *Bathyporeia* were found to be infested with *Sphaeronella*, and all the parasites observed appeared to be adult females. The body of the female, represented by the drawings, is seen to be nearly globular, particularly when viewed from above.

The antennules are three-jointed, the end joint being the longest one and the penultimate joint the smallest; they are each provided with a few setæ (fig. 18).

The maxillipeds (fig. 19) appear also to be three-jointed; the first joint is very large, but the other two are smaller; the third is armed with a moderately stout terminal claw, and as the articulation between the first and second joints forms a hinge, the last two joints, together with the terminal claw, can be folded upon the first, and this allows the maxillipeds to be used as powerful grasping organs.

No males were observed.

Habitat.—In the marsupium of *Bathyporeia pelagica* (Spence Bate), collected off Lossiemouth, Moray Firth, December 29, 1903.

Sphaeronella minuta, T. Scott, sp. n. Pl. xv., fig. 11-15.

An adult *Sphaeronella* was obtained in the marsupium of a specimen of *Perioculodes longimanus* (Spence Bate) from the Dornoch Firth, collected by the bottom tow-net on December 28, 1903. Dorsal and side views of the specimen are represented by fig. 12, 11. The length of the specimen is .48 mm. (about $\frac{1}{2}$ of an inch).

The antennules appear to be three-jointed; the first joint is nearly twice as long as the second, while the third is equal to rather more than the entire length of the first and second (fig. 13).

The first maxillipeds are very small, and consist of a single stout joint armed with a moderately strong terminal claw (fig. 14).

The second maxillipeds are rather more slender and elongated than the other pair; the basal joint is twice as long as broad; the next two are small and narrow, and appear to be hinged to the basal joint; the terminal claw, which is moderately stout, is slightly curved (fig. 15).

Dr. Hansen states that he obtained female *Sphæronellas* in the marsupiums of three specimens of *Periocolodes longimanus* from Denmark, and that they appeared to be identical with *S. paradoxa*, the only appreciable difference being their smaller size. Dr. Hansen's extensive knowledge of this curious and difficult group of Crustacea precludes any doubt concerning the accuracy of the identification of these specimens. I am therefore inclined to regard the *Sphæronella* found on the *Periocolodes* from the Dornoch Firth as a somewhat different form from those he observed, and have described it provisionally under a distinct specific name.

This *Sphæronella* from the Dornoch Firth *Periocolodes* appears to differ not only in size and shape from *S. paradoxa*, but also in the size and proportional lengths of the joints of the antennules and in the size and structure of the second maxillipeds.

Sphæronella callisomæ, T. Scott, sp. n. Pl. xv., fig. 20-27.

The *Sphæronella* I record under this name was obtained on a specimen of *Callisoma crenata* (Spence Bate) collected at the mouth of the Firth of Clyde on February 7, 1899. The parasite is an adult female and measured .86 mm. in length ($= \frac{1}{29}$ of an inch). The body seen from above is nearly globular, and the cephalon is seen projecting somewhat beyond the anterior aspect in the form of a moderately conspicuous tubercle (fig. 21). Seen from the side the body is broadly oblong, with both the anterior and posterior ends boldly convex. The anterior portion of the body appears to be thickly beset with minute hairs (fig. 20 and 21).

The antennules are three-jointed; the middle joint is very short, but the other two are moderately elongated (fig. 22).

The antennæ are very small and uniarticulate, and are each furnished with a single terminal seta about as long as the antennal joint (fig. 23).

The mandibles are slender, elongated, and sub-cylindrical (fig. 24).

The maxillæ are stout, and are each apparently composed of a single piece, and armed with two moderately stout terminal setæ, while a third seta springs from a minute lateral process, as shown in the drawing (fig. 25).

The first and second maxillipeds have each of them moderately stout basal joints, and they are each provided with strong terminal claws (fig. 26, 27).

The ventral filament, which is furnished with a terminal sucker-like disc, is long and slender, and twisted upon itself as shown in fig. 20.

This *Sphæronella* does not agree with any described species known to me.

Sphæronella cluthæ, T. Scott, sp. n. Pl. xv., fig. 28-30.

A single adult female of this *Sphæronella* was obtained in the marsupium of a specimen of *Harpinia pectinata*, G. O. Sars,* found in a tow-net gathering collected in moderately deep water at the mouth of the Clyde estuary, and nearly midway between Ailsa Craig and Sanda Island; this tow-net gathering was collected on November 14, 1899.

* Some remarks on the distribution of this *Harpinia* will be found among the Notes on Amphipoda at page 256.

This parasite, which appears to differ from any other *Sphaeronella* known to me, measures .74 mm. in length (about $\frac{1}{34}$ of an inch). Its form is almost globular, especially the dorsal view, but seen from the side the height is rather less than the width (fig. 28, 29).

The only appendages that could be satisfactorily made out were the second maxillipeds, and these are moderately elongated and slender, and are each provided with a slender terminal claw (fig. 30).

There does not appear to be any previous record of a *Sphaeronella* having been found on *Harpinia pectinata*.

Sphaeronella pygmaea, T. Scott, sp. n. Pl. xv., fig. 31-34.

The adult female of this species represented by the drawings (fig. 31 and 32), whether viewed dorsally or from the side, is seen to be of a nearly oval form, the length being equal to about one and a half times the breadth. This parasite, which is very small, measures only .49 mm. in length (about $\frac{1}{51}$ of an inch).

The antennules and antennæ appear to be rudimentary, while the only appendages of which a satisfactory examination was made were the first and second maxillipeds represented by the drawings (fig. 33, 34).

The first maxillipeds, which are very small and uniarticulate, are armed with a moderately stout terminal claw (fig. 33).

The second maxillipeds are elongated and three-jointed; the inner distal angle of the first joint is produced so as to form a small bifid projection; the first and second joints are sub-equal in length; the third is small and narrow, and bears a somewhat feeble terminal claw (fig. 34).

Habitat.—This small *Sphaeronella* was obtained in the marsupium of a specimen of *Pseudocuma similis*, G. O. Sars. No males or post-larval females were observed.

There does not appear to be any previous record of a *Sphaeronella* from this species of *Pseudocuma*.

Sphaeronella amphiloichi, H. J. Hansen. Pl. xv., fig. 35, 36.

1897. *Sphaeronella amphiloichi*, H. J. H., op. cit., p. 139, pl. vii., fig. 3 a and b.

The *Sphaeronella* I record under this name was found in the marsupium of *Amphilochoides odontonyx* (Boeck) (= *Amphilochoides pusillus*, G. O. Sars).* The specimen represented by the drawing (fig. 35) is a young female, and as Dr. Hansen has only described the adult form of the species from a solitary example, a satisfactory comparison between our specimen and his description and figures could not be made. Dr. Hansen's specimen was, however, found on the same species of Amphipod, and this favours the identification of the two parasites as being the old and young females of the same species. The young female I am recording measured only .14 mm. in length (about $\frac{1}{70}$ of an inch), but the size of the adult described by Dr. Hansen was .54 mm.

A specimen which appeared to be an adult female was taken from the marsupium of the same Amphipod in which the young one now recorded was obtained, but it was somehow lost ere it could be thoroughly examined and figured.

The posterior part of the body of the young female is distinctly hispid, and the thoracic legs were furnished with long and slender terminal hairs, as shown in fig. 35. Near the middle of the dorsal aspect a number of slender bristles were observed.

* Crustacea of Norway, vol. i. (Amphipoda), p. 222. See also the supplement to the volume, p. 690, where the author restores Boeck's name, *A. odontonyx*, for the name used in the body of the work.

The second maxillipeds were moderately powerful, but the other appendages were smaller and weaker.

As this young female agrees with none of the other young forms described by Dr. Hansen, I prefer for the present to regard it as the post larval stage of his *Sphæronella amphiloichi*.

As a list of the genera and species of the Choniostomatidæ described by Dr. H. J. Hansen in his interesting work on that curious group of parasitic Copepoda may be useful, I give it here. To this list I have added the few odd forms mentioned in the preceding notes, and one or two others recorded in previous Reports. The names of the hosts on which the parasites have been obtained are also given, and I have indicated by an asterisk (*) such of the species as up till now have been observed in Scottish waters. This will show how much room still remains for further research among these minute organisms.

The names of the parasites are arranged in alphabetical order on the left-hand side of the page, while the names of the hosts on which they have been found are placed immediately opposite.

Names of the Parasites.	Names of the Hosts.
Gen. <i>Aspiloecia</i> . * <i>Aspiloecia normani</i> , Giard and Bonnier.	<i>Erythrops elegans</i> , G. O. Sars ; <i>E. serrata</i> , G. O. Sars ; <i>E. erythrophthalmus</i> (Goës.) ; <i>E. microphthalmus</i> , G. O. Sars ; and <i>E. abyssorum</i> , G. O. Sars.
Gen. <i>Choniostoma</i> . <i>Choniostoma hansenii</i> , Giard and Bonnier. <i>Choniostoma mirabilis</i> , H. J. Hansen.	<i>Hippolyte gaimardii</i> , M.-Edw. and <i>H. polaris</i> (Sabine). „ <i>gaimardii</i> , M.-Edw.
Gen. <i>Homæoscelus</i> . <i>Homæoscelus mediterranea</i> , H. J. H. <i>Homæoscelus minuta</i> , H. J. H.	<i>Iphinoë trispinosa</i> (Goodsir). <i>Diastylis lucifera</i> (Kröyer).
Gen. <i>Mysidion</i> . <i>Mysidion abyssorum</i> , H. J. H. „ <i>commune</i> , H. J. H.	<i>Erythrops abyssorum</i> , G. O. Sars. <i>Erythrops serrata</i> , G. O. S.; <i>E. abyssorum</i> , G. O. S.; and <i>Parerythrops obesa</i> , G. O. S.
Gen. <i>Sphæronella</i> , H. J. H.	
(a) <i>Sphæronellas</i> parasitic on Amphipoda.	
<i>Sphæronella abyssi</i> , H. J. H. „ <i>acanthozonis</i> , H. J. H. * „ <i>amphiloichi</i> , H. J. H. „ <i>antillensis</i> , H. J. H. „ <i>argissæ</i> , H. J. H.	<i>Astyra abyssi</i> , Boeck. <i>Acanthozone cuspidata</i> (Lepech.). <i>Amphilochoides odontonyx</i> (Boeck). (= <i>Amphilochoiules pusillus</i> , G. O. Sars). <i>Corophium bonelii</i> , M.-Edw. <i>Argissa hamatipes</i> , Norman (= <i>A. typica</i> , Boeck).

of the Fishery Board for Scotland.

Names of the Parasites.	Names of the Hosts.
<i>Sphæronella atyli</i> , H. J. H.	<i>Paratylus svammerdami</i> (M.-Edw.).
„ <i>bonnieri</i> , H. J. H.	<i>Protomeelia fasciata</i> , Kröyer.
„ <i>caliopii</i> , H. J. H.	<i>Calliopius læviusculus</i> (Kröyer).
* „ <i>callisomæ</i> , T. Scott.	<i>Callisoma crenata</i> , Spence Bate.
„ <i>capensis</i> , H. J. H.	<i>Lemboides afer</i> , Stebbing.
„ <i>chinensis</i> , H. J. H.	<i>Corophium bonellii</i> , M.-Edw.
* „ <i>cluthæ</i> , T. Scott.	<i>Harpinia pectinata</i> , G. O. Sars.
„ <i>danica</i> , H. J. H.	<i>Corophium crassicorne</i> (Bruz.).
„ <i>dulichie</i> , H. J. H.	<i>Dulichia monocantha</i> , Metzger.
„ <i>elegantula</i> , H. J. H.	<i>Cheirocrates sundewalli</i> (Rathke).
„ <i>frontalis</i> , H. J. H.	<i>Ampelisca macrocephala</i> , Lillj.
„ <i>giardii</i> , H. J. H.	<i>Protomeelia fasciata</i> , Kröyer.
„ <i>gitanopsidis</i> , H. J. H.	<i>Gitanopsis arctica</i> , G. O. Sars.
„ <i>holbolli</i> , H. J. H.	<i>Paramphithoë boeckii</i> , H. J. H.
„ <i>intermedia</i> , H. J. H.	<i>Bruzelia typica</i> , Boeck.
„ <i>irregularis</i> , H. J. H.	<i>Metopa rubrovittata</i> , G. O. Sars.
„ <i>leptocheira</i> , H. J. H.	<i>Leptocheirus guttatus</i> , Grube.
„ <i>longipes</i> , H. J. H.	<i>Ampelisca tenuicornis</i> , Lillj.
„ <i>messinensis</i> , H. J. H.	<i>Gammaropsis melanops</i> , G. O. Sars.
„ <i>metopæ</i> , H. J. H.	<i>Metopa bruzelii</i> (Goës.).
„ <i>microcephala</i> , Giard and Bonnier.	<i>Ampelisca typica</i> , Spence Bate.
* „ <i>minuta</i> , T. Scott.	<i>Periocolodes longimanus</i> (Spence Bate).
* „ <i>paradoxa</i> , H. J. H.	<i>Bathyporeia norvegica</i> , G. O. Sars ; <i>B. pelagica</i> (Bate) ; and <i>B. robertsoni</i> (Bate).
„ <i>vestita</i> , H. J. H.	<i>Microprotopus maculatus</i> , Norman.
(b) <i>Sphæronellas</i> parasitic on Isopoda.	
<i>Sphæronella affinis</i> , H. J. H.	<i>Janira maculosa</i> , Leach.
„ <i>curtipes</i> , H. J. H.	„ <i>spinosa</i> , Harger.
„ <i>munropsidis</i> , H. J. H.	<i>Munnopsis typica</i> , M. Sars.
(c) <i>Sphæronellas</i> parasitic on Sympoda.	
<i>Sphæronella decorata</i> , H. J. H.	<i>Diastylis rathkei</i> , Kröyer.
„ <i>dispar</i> , H. J. H.	<i>Eudorella truncatula</i> (Spence Bate).
„ <i>insignis</i> , H. J. H.	<i>Diastylis cornuta</i> , Boeck ; and <i>D. rostratus</i> , Goodsir (= <i>D. levis</i> Norman).
„ <i>marginata</i> , H. J. H.	<i>Iphinoë trispinosa</i> (Goodsir).
„ <i>modesta</i> , H. J. H.	<i>Eudorella emarginata</i> (Kröyer).
* „ <i>pygmæa</i> , T. Scott.	<i>Pseudocuma similis</i> , G. O. Sars.
Gen. <i>Stenothocheres</i> , H. J. H.	
* <i>Stenothocheres egregius</i> , H. J. H.	<i>Metopa bruzelli</i> (Goës), and
„ <i>sarsi</i> , H. J. H.	<i>Metopa borealis</i> , G. O. Sars. <i>Stenothoë marina</i> , Spence Bate.
Gen. <i>Salenskya</i> , Giard and Bonnier.	
* <i>Salenskya tuberosa</i> , Giard and Bonnier.	<i>Ampelisca spinipes</i> , Boeck.

AMPHIPODA.

The following notes on some species belonging to the Amphipoda and one or two other groups of the Malacostraca obtained in plankton—samples collected during the investigations recently carried out by Dr. T. Wemyss Fulton in the North Sea and the Moray Firth—may be of interest.

' *Hyperia medusarum* (O. F. Muller). This species, which appears to have a decidedly northern and Arctic distribution, and of which there is so far no authentic British record, was obtained in a surface plankton-sample collected about 180 to 185 miles east by north of Aberdeen on October 8th, 1903. One or two full-grown females and several young specimens were noticed. In the same gatherings there were observed *Clione borealis* and *Limacina retroversa*—two northern Pteropods—as well as *Tryphosa nanoides*, *Hoplonyx cicada*, and some other and commoner forms.

Tryphana malmi, Boeck. This curious and brightly coloured little Amphipod occurred in a surface gathering collected off the Ord of Caithness, Moray Firth, on November 21st, and in a bottom gathering collected off Lossiemouth on December 29th, 1903. This is the first time I have met with *Tryphana* so close to the Scottish north-east coast, but the Rev. Canon A. M. Norman records its occurrence at Banff, whence specimens were sent to him many years ago by Thomas Edward.* Professor G. O. Sars in his great work on the Crustacea of Norway records this species from three different places on the west coast of Norway, and only from deep water; he states further that Boeck also obtained it in deep water in Hardangerfjord.† The only other localities which Norman gives in his note on the distribution of the species are the Faroe Isles and North Atlantic, lat. 18° 8', long. 30° 5' W. (Stebbing). *Tryphana malmi* may, however, be less rare than the apparent dearth of information concerning its distribution would seem to imply. I have obtained it in at least two plankton-samples from the Shetland Islands, in addition to the two mentioned above.‡

Anonyx nugax (Phipps). This species, rarely met with in the British seas, was captured in Aberdeen Bay on December 23rd, 1903. The species was taken for the first time in Scottish waters in February, 1889; on that occasion it was obtained near May Island, at the mouth of the Forth estuary.§ It was again met with in January, 1901, in the Cromarty Firth, when specimens collected on the 10th of that month by Mr. F. G. Pearcey were forwarded to the Fishery Board's Laboratory at Bay of Nigg, near Aberdeen,|| and the present record of its occurrence in Aberdeen Bay is the only other occasion on which it has been observed off the east coast of Scotland. None of the Scottish specimens of *Anonyx nugax* have attained to anything like the size of some Arctic examples.

Hoplonyx cicada (Fabricius). This species, which, like the last, is also a northern form, has already been referred to in the note on *Hyperia*

* British Amphipoda of the Tribe Hyperiidæ, &c., *Ann. and Mag. Nat. Hist.*, (7), vol. v., p. 133 (January 1900).

† Crustacea of Norway, vol. i., Amphipoda, p. 18.

‡ Conseil permanent International pour l'exploration de la Mer; Bull. des Results, Pt. D., for August, 1903, pp. 44-47.

§ Eleventh Ann. Rept. of the Fishery Board for Scotland, Part III., p. 212, pl. v., fig. 18-20 (1893).

|| Nineteenth Ann. Rept. of the Fishery Board for Scotland, Pt. III., p. 258 (1901).

medusarum ; but the largest specimen observed in the collections under consideration was obtained in the same gathering with *Anonyx nugar*, from Aberdeen Bay. Though the species appears to be widely distributed along the west side of the British Islands, the records of its occurrence on the east coast of Scotland appear to be very few, and its presence in Aberdeen Bay is all the more interesting.

It may be stated that the gathering from Aberdeen Bay collected on December 23rd, 1903, contained a considerable number of other species of Amphipoda besides the two I have specially mentioned, and the names of the following may be given, *Acidostoma obesum*, *Tryphosa longipes*, *Ampelisca spinipes*, *Iphimedeia minuta*, and one or two fine specimens of *Amathilla homari*. Specimens of *Diastylis rostrata* and *Siriella armata* were also observed.

Harpinia pectinata, G. O. Sars. The occurrence of the single specimen of *Harpinia pectinata* already mentioned in connection with *Sphæronella cluthæ*, whose host it was, is of sufficient interest to be specially referred to in these notes. The only stations that may be considered as within the British limits where this species has hitherto been observed "are all to the west of Ireland and between Ireland and Rockall."* Its capture at the mouth of the Clyde estuary may be an indication that it may be found in other places when carefully sought for. *H. pectinata*, which seems to be confined to moderately deep water, is a form that may easily be mistaken for a more common species, the characters by which it is distinguished being not easily made out without dissection. Professor G. O. Sars speaks of it as being "by no means rare" off the south and west coasts of Norway and occurring, as a rule, in company with *H. neglecta*. The Rev. T. R. R. Stebbing has seen the Clyde specimen and confirms my identification.

Metopa borealis, G. O. Sars. The occurrence of this species in Aberdeen Bay has already been referred to under the Choniostomatidæ as one of the hosts of *Stenothocheres egregius*. *Metopa borealis*, like *M. alderi* and one or two other members of the same genus, has an unarmed telson, but with the assistance of Professor G. O. Sars' excellent monograph, it need not be confounded with any of the other species referred to. *M. borealis* is a northern form, but appears to have a fairly wide distribution ; it is one of the rarer forms recorded by Dr. Robertson from the Firth of Clyde.

Paratylus falcatus, Metzger. One or two specimens of *Paratylus falcatus* were obtained in a tow-net gathering collected in the Dornoch Firth on December 26th, 1903. Though this *Paratylus* bears a strong resemblance to *P. uncinatus*, G. O. Sars, the tooth-like posterior projections of the segments of the metasome on the dorsal aspect readily distinguish it. I have found both forms in Scottish waters, but neither of them very common.

Megaluropus agilis, Norman. This somewhat curious species, readily distinguished by the peculiar form of the eyes, was obtained in a bottom plankton-sample collected on December 29th about three miles off Lossiemouth, Moray Firth.

ISOPODA.

Idothea neglecta, G. O. Sars. Professor G. O. Sars in his great work on the Crustacea of Norway, now in course of publication, has in Volume II.

* British Amphipoda, by Rev. A. M. Norman ; *Ann. and Mag. Nat. Hist.*, (7), vol. v., p. 337 (April, 1900).

(Isopoda) described as distinct species one or two forms which previously have apparently been included with the Isopod known as *Idotea tricuspidata*, which was in consequence considered to be a variable species. One of the forms referred to, which Professor Sars has raised to specific rank is named by him *Idothea neglecta*,* and he states concerning it that it "occurs along the whole Norwegian coast from Christiania Fjord to Vadsö, and is often found in great abundance among decaying algæ in depths ranging from six to twenty fathoms." This form is probably not uncommon round the coasts of Scotland, and is, I think, included among the varieties of '*Idotea tricuspidata*' described in Bate and Westwood's Sessile-eyed Crustacea.† *Idothea neglecta* appears to be moderately frequent in some parts of the Clyde estuary; my friend Mr. Alexander Patience of Glasgow, who first directed my attention to its occurrence in the Clyde, has obtained a considerable number of specimens, which he has been kind enough to let me examine, and there are several specimens in the collection in the Fishery Board's Laboratory, Bay of Nigg, which are also from the Clyde district. The average size of the male of this *Idothea* is stated by Sars to be 25 millimetres in length (=1 inch). One of the specimens in the Laboratory is, however, much larger than that, being 33 millimetres, while others in the same collection measure 28, 27, 25, and 20 millimetres. The female is much smaller than the male, its average size being, according to Sars, only 16 millimetres. All the specimens in the Laboratory have been collected in different parts of upper Loch Fyne during 1897 and 1899.

Idothea neglecta has not yet been recorded from the east coast of Scotland.

SYMPODA.

Eudorellopsis deformis (Kröyer). This curious little species was obtained in a plankton-sample collected by the s.s. "Glenogle" about fifty miles to the eastward of the May Island, Firth of Forth, on August 20th, 1903; the species has been observed in various other localities, but very sparingly and usually in moderately deep water.

Pseudocuma similis, G. O. Sars. This species has already been referred to as the host of *Sphæronella pygmæa* under the Choniostomatidæ; a few specimens occurred in a plankton-sample collected in moderately deep water about three miles off Lossiemouth, in the Moray Firth, on December 29th, 1903. *Pseudocuma similis* resembles the more common *P. cercaria* very closely, and this may be the reason it has only recently been recognised as a British species.

A considerable number of other microcrustaceans, more or less interesting, have been noticed in various plankton-samples collected during the recent fishery investigations carried out under the direction of Dr. Fulton in the North Sea and Moray Firth. These may be described in a subsequent paper dealing more generally with that group of marine organisms.

I take this opportunity to substitute other generic names in room of two that have recently been adopted for certain forms of Copepoda, but which I now find to be pre-occupied.

(a). Genus *Platypsyllus*, T. Scott, *Twentieth Report of the Fishery Board for Scotland* (1902), Pt. III., p. 455. I find that *Platypsyllus* was used in 1869 both by Dr. Ritsema and Professor Westwood for a

* Crustacea of Norway, vol. ii., p. 84., pl. xxxv, fig. 1.

† British Sessile-eyed Crustacea, vol. ii., p. 381, text figs.

genus of Coleoptera, its use by me for a genus of Copepoda must therefore apse, and the name I propose to substitute for it is *Jeanella*, the diminutive of the proper name Jean.

(b) Genus *Paranthessius*, T. Scott, *Twenty-first Report of the Fishery Board for Scotland* (1903), Pt. III., p. 120. This name has already been used by Professor Claus for a genus of Copepoda different from that described in the Report mentioned, and it must therefore be replaced by another, and the name I propose to substitute for it is *Heteranthessius*.

DESCRIPTION OF THE PLATES.

PLATE XIII.

Monstrilla longicornis, I. C. Thompson.

Diam.

Fig. 1.	Female, dorsal view	.	.	.	.	.	.	x 26.5.
Fig. 2.	Male, dorsal view	.	.	.	.	.	.	x 35.
Fig. 3.	Antennule, female	.	.	.	.	.	.	x 40.
Fig. 4.	Fifth pair of thoracic feet, female	.	.	.	.	.	.	x 53.
Fig. 5.	Abdomen and caudal furca, female	.	.	.	.	.	.	x 80.
Fig. 6.	Antennule, male	.	.	.	.	.	.	x 53.
Fig. 7.	Abdomen and caudal furca, male, ventral aspect	.	.	.	.	.	.	x 80.

Monstrilla gracilicauda, Giesbrecht.

Fig. 8.	Female, dorsal view	.	.	.	.	.	.	x 35.
Fig. 9.	Antennule, female	.	.	.	.	.	.	x 53.
Fig. 10.	Abdomen and caudal furca, female,	.	.	.	.	.	.	x 79.

Monstrilla grandis, Giesbrecht.

Fig. 11.	Female, dorsal view	.	.	.	.	.	.	x 26.
Fig. 12.	Male, dorsal view	x 35.

Monstrilla anglica, Lubbock.

Fig. 13.	Female, dorsal view	x 21.
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Monstrilla dubia, T. Scott, sp. n.

Fig. 14.	Female, dorsal view	x 26.
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Thaumaleus rigidus, I. C. Thompson.

Fig. 15.	Female, dorsal view	x 35.
Fig. 16.	Antennule, female	x 130.
Fig. 17.	Fifth pair of thoracic feet, female	.	.	.	.	.	.	x 130.

Thaumaleus zelandicus, T. Scott, sp. n.

Fig. 18.	Female, dorsal view	.	.	.	.	.	.	x 21.
Fig. 19.	Male, dorsal view	.	.	.	.	.	.	x 21.

PLATE XIV.

Thaumaleus thompsoni, Giesbrecht.

Fig. 1.	Female, dorsal view	.	.	.	.	.	.	x 20.5.
Fig. 2.	Antennule, female	.	.	.	.	.	.	x 79.
Fig. 3.	Fifth pair of thoracic feet, female	.	.	.	.	.	.	x 79.
Fig. 4.	Abdomen and caudal furca, female	.	.	.	.	.	.	x 97.

Thaumaleus rostratus, T. Scott, sp. n.

						Diam.
Fig. 5.	Female, dorsal view	.	.	.	.	× 26.5.
Fig. 6.	Antennule, female	.	.	.	.	× 79.
Fig. 7.	Fifth pair of thoracic feet, female	.	.	.	.	× 79.
Fig. 8.	Abdomen and caudal furca, female	.	.	.	.	× 79.

Monstrilla grandis, Giesbrecht.

Fig. 9.	Antennule, female	.	.	.	.	× 53.
Fig. 10.	Fifth pair of thoracic feet, female	.	.	.	.	× 79.
Fig. 11.	Abdomen and caudal furca, female	.	.	.	.	× 72.

Monstrilla anglica, Lubbock.

Fig. 12.	Antennule, female	.	.	.	.	× 53.
Fig. 13.	Fifth pair of thoracic feet, female	.	.	.	.	× 79.
Fig. 14.	Abdomen and caudal furca, female	.	.	.	.	× 97.

Monstrilla gracilicauda, Giesbrecht.

Fig. 15.	Fifth pair of thoracic feet, female	× 79.
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Monstrilla dubia, T. Scott, sp. n.

Fig. 16.	Antennule, female	× 64.
Fig. 17.	Fifth pair of thoracic feet, female	× 106.
Fig. 18.	Abdomen and caudal furca, female	.	.	.	.	× 79.

Thaumaleus rigidus, I. C. Thompson.

Fig. 19.	Abdomen and caudal furca, female	× 130.
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Thaumaleus zetlandicus, T. Scott, sp. n.

Fig. 20.	Antennule, female	× 64.
Fig. 21.	Fifth pair of thoracic feet, female	× 79.
Fig. 22.	Abdomen and caudal furca, female	.	.	.	.	× 79.

PLATE XV.

Monstrilla grandis, Giesbrecht.

Fig. 1.	Antennule, male	.	.	.	.	× 53.
Fig. 2.	Abdomen and caudal furca, female	.	.	.	.	× 106.

Thaumaleus zetlandicus, T. Scott, sp. n.

Fig. 3.	Antennule, male	.	.	.	.	× 53.
Fig. 4.	Abdomen and caudal furca, male	.	.	.	.	× 79.

Stenothocheres egregius, Han.

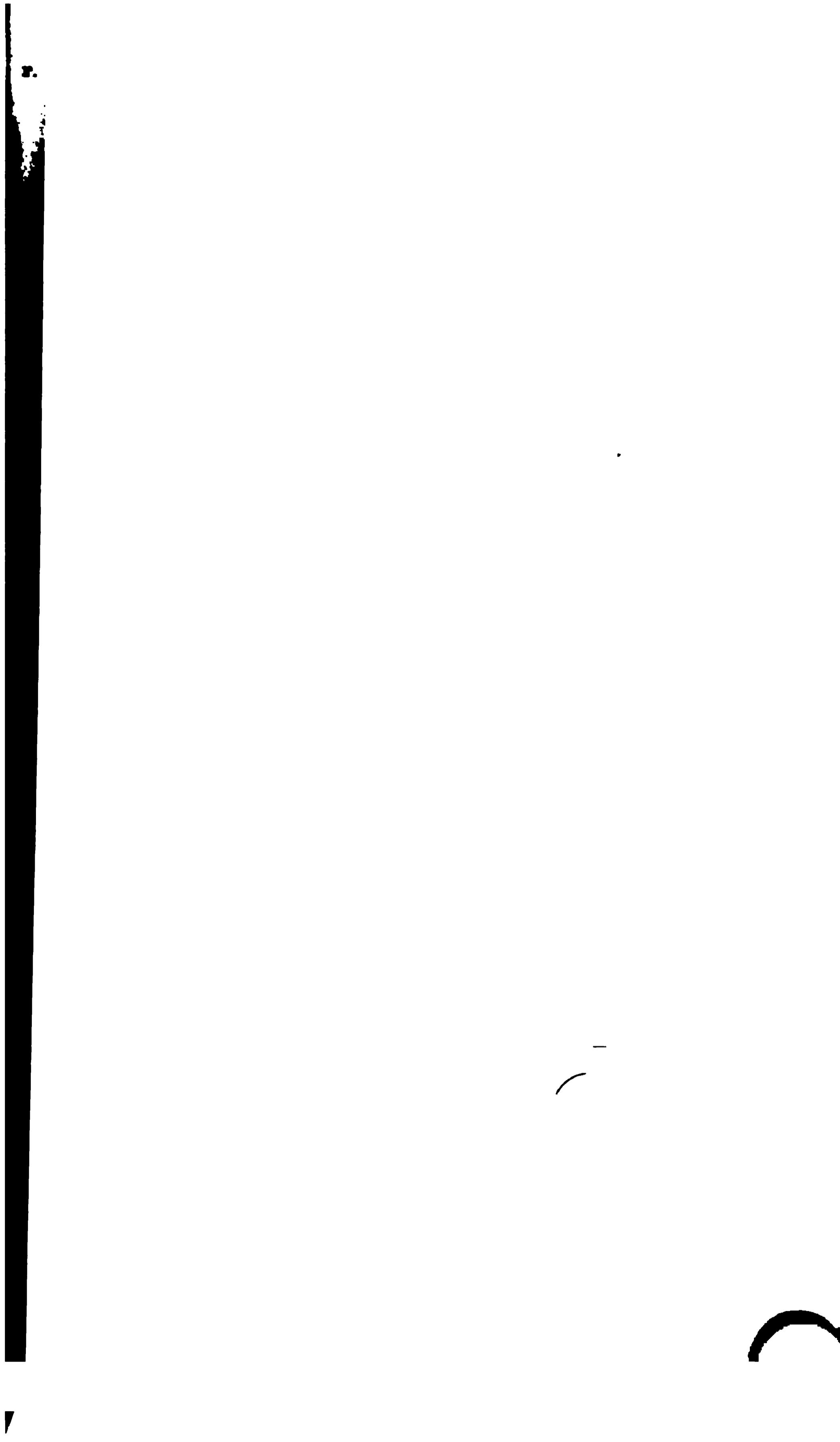
Fig. 5.	Side view, female	.	.	.	.	× 53.
Fig. 6.	Dorsal view, female	.	.	.	.	× 53.
Fig. 7.	Antennule, female	.	.	.	.	× 521.
Fig. 8.	Antenna, female	.	.	.	.	× 781.
Fig. 9.	Foot of first pair	.	.	.	.	× 781.
Fig. 10.	Foot of second pair	.	.	.	.	× 781.

Sphaeronella minuta, T. Scott, sp. n.

Fig. 11.	Female, side view	.	.	.	.	× 106.
Fig. 12.	Female, dorsal view	.	.	.	.	× 106.
Fig. 13.	Antennule	.	.	.	.	× 781.
Fig. 14.	First maxilliped	.	.	.	.	× 781.
Fig. 15.	Second maxilliped	.	.	.	.	× 781.







Sphaeronella paradoxa, Han.

							Diam.
Fig. 16.	Female, side view	.	.	.	.	.	× 79.
Fig. 17.	Female, dorsal view	.	.	.	.	.	× 79.
Fig. 18.	Antennule	.	.	.	.	.	× 781.
Fig. 19.	Maxilliped	.	.	.	.	.	× 781.

Sphaeronella callisomæ, T. Scott, sp. n.

Fig. 20.	Female, side view	.	.	.	.	.	× 53.
Fig. 21.	Female, dorsal view	.	.	.	.	.	× 53.
Fig. 22.	Antennule	.	.	.	.	.	× 390.
Fig. 23.	Antenna	.	.	.	.	.	× 781.
Fig. 24.	Mandible	.	.	.	.	.	× 781.
Fig. 25.	Maxilla	.	.	.	.	.	× 781.
Fig. 26.	First maxilliped	.	.	.	.	.	× 521.
Fig. 27.	Second maxilliped	.	.	.	.	.	× 521.

Sphaeronella cluthæ, T. Scott, sp. n.

Fig. 28.	Female, side view	.	.	.	.	.	× 64.
Fig. 29.	Female, dorsal view	.	.	.	.	.	× 64.
Fig. 30.	Second maxilliped	.	.	.	.	.	× 79·5.

Sphaeronella pygmaea, T. Scott, sp. n.

Fig. 31.	Female, side view	.	.	.	.	.	× 106.
Fig. 32.	Female, dorsal view	.	.	.	.	.	× 106.
Fig. 33.	First Maxilliped	.	.	.	.	.	× 781.
Fig. 34.	Second Maxilliped	.	.	.	.	.	× 390.

Sphaeronella amphiloichi, Han.

Fig. 35.	Female, side view	.	.	.	.	.	× 521.
Fig. 36.	Antennule of the same	.	.	.	.	.	× 781.

V.—REPORT ON THE OPERATIONS AT THE MARINE HATCHERY, BAY OF NIGG, ABERDEEN, By DR. T. WEMYSS FULTON, F.R.S.E., Superintendent of Scientific Investigations.

During the season of 1903 the operations on the hatching of plaice were continued on a considerable scale as in previous years, and under the same conditions as are described in preceding reports. It need only be stated that the supply of fertilised eggs is obtained, not by stripping the ripe fishes of their eggs and milt, as is done in some other marine fish hatcheries, but by retaining the fishes from season to season in a large tidal pond, feeding them, and at the spawning season simply collecting the eggs from the water by appropriate means, and transferring them to the hatching apparatus. For this method, a large retaining pond is necessary, and the one constructed at the Bay of Nigg has answered its purpose admirably, the fishes remaining in it throughout the year in good health and supplying their eggs at the proper period with a minimum of trouble to the attendants, and with good results in regard to the success of incubation.

One of the consequences of this system which contrasts with the condition at Dunbar, where the fishes were merely retained in the pond for some time before the spawning began, is that spawning goes on for a much longer time than used to be the case under the former system. It begins earlier and may continue longer, the dates varying with the temperature to some extent, but the extent of the season is always greater. Thus at Dunbar the collection of eggs did not as a rule commence till March, the principal reason being that the fishes had not had time to become accustomed to their restraint in confinement after being placed in the pond, and they retained their eggs instead of spawning in a natural way, very often with fatal results, as described in previous reports. In point of fact they did not spawn until they had become accustomed to the conditions in which they were placed. The respective dates for the beginning of the spawning at Dunbar and at the Bay of Nigg are as follows :—

9th March	to	8th May	=	60	days
23rd March	„	23rd May	=	61	„
8th March	„	8th May	=	61	„
22nd February	„	11th May	=	78	„
15th February	„	7th May	=	81	„
10th March	„	29th April	=	50	„
10th March	„	5th May	=	56	„
22nd January	„	2nd May	=	100	„
8th February	„	25th April	=	76	„
23rd January	„	16th May	=	113	„

It will be observed that the mean duration of the spawning process at Dunbar owing to this delay in its commencement was sixty-five days, while at the Bay of Nigg the mean duration has been eighty-six days, or twenty-one days longer. In the first season at the Bay of Nigg the hatchery was not ready in time, and in the third season the beginning of spawning was delayed by cold, though the termination, which was

earlier than usual, was natural. The ordinary duration of the spawning season of the plaice appears to be about the longer periods, extending over three full months and part of other two—and the observation is of some importance in fishery investigations.

Eggs were observed in small numbers a few days before the regular collection began, and a few were found after the date when the collection ceased. The total number of eggs secured from the pond by means of tow-nets was about 65,940,000, the eggs being measured in a vessel of known capacity and the number thus estimated. Spawning took place for the most part in March, the numbers of eggs secured in the various months being as follows:—

January,	-	-	-	240,000
February,	-	-	-	11,840,000
March,	-	-	-	37,080,000
April,	-	-	-	15,900,000
May,	-	-	-	880,000

In some years the bulk of the spawning occurs in the early part of April. On some mornings in March last year as much as five gallons of eggs were taken from the pond. Of the number of eggs collected 81 per cent. were hatched, and the remainder succumbed at one stage or another in the apparatus; there is reason to suspect that some of the eggs which are lost in this way are not fertilised, a tendency having been shown to economise the space in the pond by having in it an unduly large proportion of females at the expense of the number of males.

The estimated number of fry which were hatched and kept for a period in the apparatus was 53,600,000, and they were afterwards placed in the sea, most of them being liberated a few miles off Aberdeen, by means of a fishing yawl. At the request of the line-fishermen further up the coast a number were set free on three occasions off Fraserburgh, the total distributed there being about 16,000,000.

The particulars as to the distribution of the fry and the details as to the numbers of eggs collected throughout the season are given in the tables appended, which also show the variations in the temperature and the specific gravity of the water in the spawning pond and on the beach.

The number of fishes kept in the pond to act as the breeding stock was as usual supplemented in autumn by others caught by means of trawlers and brought alive to the hatchery in large tubs; for there is always a certain amount of natural mortality among them, particularly during the summer. The plaice, as hitherto, were fed on mussels, which are usually removed from their shells, but are sometimes only crushed.

The ponds and apparatus, which have been described in preceding annual reports, continue to serve their purpose well, and the water supply, both in regard to temperature, density, and purity, is very suitable for the work. The only changes that have been made in the arrangements consist in the removal of the water tumbling-box from the inside of the hatchery, where it was served with the incoming water, to the outside, where it is now operated by the out-flowing water. The box is necessary to provide the motive power to the Dannevig hatching apparatus, and it was found to interfere to some extent with the pressure of the water to one side of the hatchery and thus to retard the supply. Also by the fitting up of the tank-house for scientific experiments it was found necessary to divert a portion of the water from the reservoir tank for this purpose, and the change necessitated a little more pumping early in the mornings.

The question of attempting to rear the fry on a fairly large scale has been considered. It not unfrequently happens that at the end of the hatching season young metamorphosed plaice are found in some part of the apparatus, which have succeeded in passing the post-larval stages, although it is not easy to get such forms when it is attempted to rear them. The difficulty is in providing a supply of suitable food, and it is proposed to utilise a tank to act as a receptacle for spawning invertebrates, so that the water, enriched with the embryos and larvæ may be used to supply the young fishes.

For a few years the placing of the fry in Loch Fyne has been intermitted, and they have been distributed, as described, along the coast of Aberdeenshire. The reason for doing so is in order to enable observations as to the abundance of young plaice on the beaches in Loch Fyne to be made under natural conditions, without artificially reared fry being placed there in the same season, and the push-net examination of these beaches is being continued each summer. The fry were originally taken to Loch Fyne without such observations having been made beforehand, and there were therefore no data for comparing the abundance of the young plaice in the years in which the fry were put into the Loch. From the natural fluctuations which take place with fish everywhere, it is obvious that it is desirable to have observations carried on long enough to be able to distinguish one cause of fluctuation from the other, just as in cases where the influence of a method of fishing, or of stopping it, requires to be tested in the same way.

During the hatching season the hatchery was visited by deputations of fishermen from the coast of Aberdeen, as in previous years, at the request of the Technical Education Committee of the County Council, and they received demonstrations as to the processes employed.

TABLE I.—Showing the Daily Progress of the Hatching Operations, as well as the Temperature and the Specific Gravity of Water in the Pond, and on the Beach.

Date.	Number of Eggs Collected.	Number of Eggs found Dead in Boxes.	Number of Fry put out.	Total Stock in Boxes.	The Sea Water in the Pond at Noon.		The Sea Water on the Beach at Noon.	
					Temp.	Sp. gr.	Temp.	Sp. gr.
Jan. 20	...	...	...	...	Cent. 3·1	27·2	Cent. 4·2	27·2
„ 21	...	...	...	...	3·8	27·2	4·4	27·2
„ 22	...	...	...	...	4·0	27·3	5·0	27·3
„ 23	60,000	...	...	60,000	4·1	27·2	5·0	27·0
„ 24	...	...	...	...	4·2	27·4	5·1	27·0
„ 25	...	...	...	...	...	...	...	...
„ 26	40,000	...	...	100,000	4·6	27·3	5·3	27·1
„ 27	20,000	...	...	120,000	5·3	27·2	5·5	27·2
„ 28	...	...	...	...	5·4	27·2	5·4	27·0
„ 29	40,000	...	...	160,000	5·3	27·3	5·3	27·0
„ 30	40,000	...	...	200,000	5·5	27·4	5·4	27·1
„ 31	40,000	...	...	240,000	5·6	27·3	5·2	27·0
Feb. 1	...	...	...	240,000	...	...	...	...
„ 2	120,000	...	...	360,000	4·2	27·2	5·0	27·0
„ 3	40,000	...	...	400,000	4·1	27·3	5·0	27·2
„ 4	120,000	...	...	520,000	4·2	27·1	4·9	26·9
„ 5	280,000	...	...	800,000	4·0	27·4	4·6	27·0
„ 6	40,000	60,000	...	780,000	4·0	27·3	5·1	27·1
„ 7	200,000	...	...	980,000	...	...	...	...
„ 8	...	...	...	980,000	...	...	...	...
„ 9	400,000	...	...	1,380,000	4·4	27·1	4·8	27·3
„ 10	200,000	...	...	1,580,000	4·6	27·2	5·0	27·0
„ 11	320,000	80,000	...	1,820,000	4·4	27·2	4·9	27·1
„ 12	160,000	...	...	1,980,000	...	...	...	...
„ 13	320,000	...	...	2,300,000	...	...	...	...
„ 14	200,000	...	...	2,500,000	...	...	...	...
„ 15	...	...	...	2,500,000	4·8	27·4	5·1	27·0
„ 16	480,000	120,000	...	2,860,000	5·2	27·3	5·3	27·1
„ 17	560,000	...	...	3,420,000	5·4	27·5	5·2	27·0
„ 18	480,000	...	...	3,900,000	5·7	27·3	5·6	27·2
„ 19	600,000	...	...	4,500,000	6·2	27·2	6·0	27·1
„ 20	800,000	...	...	5,300,000	6·0	27·3	6·0	26·8
„ 21	...	260,000	...	5,040,000	5·8	27·4	5·9	27·0

TABLE I.—continued.

Date.	Number of Eggs Collected.	Number of Eggs found Dead in Boxes.	Number of Fry put out.	Total Stock in Boxes.	The Sea Water in the Pond at Noon.		The Sea Water on the Beach at Noon.	
					Temp.	Sp. gr.	Temp.	Sp. gr.
Feb. 22	1,320,000	...	...	6,360,000	Cont. 5·5	27·2	Cont. 5·9	27·0
„ 23	880,000	...	...	7,240,000	4·8	27·3	5·7	27·0
„ 24	320,000	...	...	7,560,000	4·4	27·2	5·4	27·1
„ 25	1,240,000	100,000	...	8,700,000	4·6	27·3	5	27·0
„ 26	880,000	...	...	9,580,000	4·4	27·4	5·3	...
„ 27	1,160,000	140,000	...	10,600,000	4·5	27·2	5·0	27·2
„ 28	720,000	...	...	11,320,000	4·6	27·2	5·1	...
Mar. 1	...	...	...	11,320,000	4·8	27·3	5·0	27·0
„ 2	1,680,000	320,000	...	12,680,000	4·7	27·5	5·0	27·1
„ 3	1,200,000	...	...	13,880,000	4·4	27·2	5·0	27·0
„ 4	1,040,000	...	...	14,920,000	4·8	27·1	5·3	27·8
„ 5	1,160,000	...	...	16,080,000	4·6	27·2	5·2	27·0
„ 6	980,000	380,000	...	16,680,000	4·8	27·2	5·1	27·0
„ 7	960,000	220,000	...	17,420,000	4·9	27·0	5·0	27·1
„ 8	...	...	...	17,420,000	5·0	27·4	5·1	27·0
„ 9	1,720,000	...	...	19,140,000	4·8	27·3	5·1	27·9
„ 10	1,600,000	480,000	...	20,260,000	5·0	27·5	5·2	27·1
„ 11	1,280,000	...	...	21,540,000	4·7	27·2	5·0	27·2
„ 12	960,000	270,000	...	22,230,000	4·9	27·5	5·1	27·2
„ 13	1,320,000	...	...	23,550,000	5·1	27·4	5·3	27·0
„ 14	1,440,000	220,000	...	24,770,000	5·3	27·4	5·3	27·1
„ 15	...	...	...	24,770,000	5·2	27·3	5·2	27·2
„ 16	2,000,000	330,000	4,000,000	22,440,000	5·4	27·4	5·1	27·0
„ 17	...	...	...	22,440,000	5·0	27·2	5·4	27·0
„ 18	2,360,000	360,000	...	24,440,000	5·2	27·4	5·2	27·2
„ 19	1,160,000	260,000	...	25,340,000	5·6	27·5	5·1	27·0
„ 20	1,200,000	460,000	3,800,000	22,280,000	5·5	27·3	5·2	27·9
„ 21	2,060,000	...	...	24,340,000	5·4	27·5	5·4	27·1
„ 22	...	360,000	...	23,980,000	5·9	27·6	5·2	27·3
„ 23	3,500,000	400,000	...	27,080,000	6·2	27·4	5·4	27·4
„ 24	1,280,000	320,000	...	28,040,000	6·0	27·3	5·8	27·2
„ 25	1,520,000	220,000	...	29,340,000	5·8	27·3	5·8	27·1

TABLE I.—continued.

Date.	Number of Eggs Collected.	Number of Eggs found Dead in Boxes.	Number of Fry put out.	Total Stock in Boxes.	The Sea Water in the Pond at Noon.		The Sea Water on the Beach at Noon.	
					Temp.	Sp. gr.	Temp.	Sp. gr.
Mar. 26	1,220,000	260,000	4,300,000	26,000	Cent. ...	...	Cent. ...	...
„ 27	1,240,000	320,000	...	26,920	6·0	27·2	5·8	27·3
„ 28	...	280,000	...	26,640,000	6·2	27·3	5·8	27·1
„ 29	1,960,000	...	...	28,600,000	6·4	27·5	5·8	27·2
„ 30	...	450,000	...	28,150,000	6·3	27·4	5·9	27·5
„ 31	2,240,000	340,000	...	30,050,000	6·1	27·2	6·0	27·3
April 1	...	...	4,000,000	26,050,000	6·2	27·6	5·8	27·4
„ 2	2,040,000	420,000	...	27,670,000	6·4	27·3	5·9	27·3
„ 3	...	...	...	27,670,000	6·1	27·1	6·2	27·0
„ 4	1,560,000	520,000	...	28,710,000	6·6	27·4	6·2	27·2
„ 5	1,040,000	...	...	27,750,000	...	...	...	...
„ 6	...	280,000	6,000,000	23,470,000	6·4	27·5	6·3	27·1
„ 7	...	480,000	...	22,990,000	6·1	27·3	6·2	27·4
„ 8	1,960,000	300,000	...	24,650,000	6·4	27·6	6·2	27·3
„ 9	1,160,000	...	...	25,810,000	7·0	27·3	6·6	27·2
„ 10	560,000	470,000	...	25,900,000	7·2	27·4	6·8	27·0
„ 11	800,000	...	...	26,700,000	6·8	27·7	6·6	27·3
„ 12	720,000	...	...	27,420,000	7·0	27·8	6·4	27·0
„ 13	...	320,000	...	27,100,000	6·8	27·6	6·4	27·4
„ 14	1,220,000	...	...	28,320 000	6·5	27·4	6·1	27·8
„ 15	440,000	280,000	8,000,000	20,480,000	6·0	27·5	6·0	27·3
„ 16	400,000	...	...	20,880,000	5·9	27·8	6·1	27·4
„ 17	400,000	400,000	...	20,880,000	5·4	27·4	6·0	27·2
„ 18	...	...	...	20,880,000	5·1	27·6	5·8	27·7
„ 19	800,000	320,000	...	21,360,000	5·0	27·3	5·8	27·4
„ 20	440,000	...	4,400,000	17,400,000	4·8	27·2	5·1	27·2
„ 21	340,000	240,000	...	17,500,000	4·9	27·4	...	...
„ 22	400,000	260,000	...	17,640,000	5·0	27·3	...	...
„ 23	400,000	...	...	18,040,000	...	...	...	...
„ 24	...	...	...	18,040,000	5·8	27·4	5·8	27·2
„ 25	...	340,000	...	17,700,000	6·4	27·6	6·1	27·5
„ 26	820,000	...	...	18,520,000	6·6	27·5	6·4	27·3

TABLE I.—continued.

Date.	Number of Eggs Collected.	Number of Eggs found Dead in Boxes.	Number of Fry put out.	Total Stock in Boxes.	The Sea Water in the Pond at Noon.		The Sea Water on the Beach at Noon.	
					Temp.	Sp. gr.	Temp.	Sp. gr.
April 27	...	180,000	...	18,340,000	Cent. 6·3	27·8	Cent. 6·1	27·3
„ 28	...	...	...	18,340,000	6·0	27·5	6·2	27·5
„ 29	...	160,000	...	18,180,000	6·4	27·3	6·2	27·2
„ 30	400,000	...	7,300,000	11,281,000	...	...	...	...
May 1	...	...	...	11,281,000	...	...	...	...
„ 2	...	...	...	11,281,000	...	...	...	...
„ 3	400,000	...	...	11,680,000	...	...	...	...
„ 4	...	160,000	...	11,520,000	...	...	...	...
„ 5	300,000	...	...	11,820,000	...	...	...	...
„ 6	...	...	...	11,820,000	...	...	...	...
„ 7	...	...	5,500,000	6,320,000	7·0	27·2	7·3	...
„ 8	...	...	...	6,320,000	7·6	27·3	7·4	...
„ 9	...	...	...	6,320,000	8·0	27·5	7·2	...
„ 10	60,000	140,000	...	6,240,000	8·4	27·1	7·6	...
„ 11	...	...	...	6,240,000	8·3	27·2	7·7	...
„ 12	...	60,000	...	6,180,000	7·5	27·3	7·2	...
„ 13	60,000	...	...	6,240,000	8·1	27·5	7·4	...
„ 14	...	...	4,800,000	1,940,000	8·8	27·4	7·6	...
„ 15	40,000	...	...	1,980,000	8·6	27·2	7·3	...
„ 16	20,000	...	...	2,000,000	9 1	27·4	7·8	...
„ 17	...	...	...	...	...	...	...	...
„ 18	...	...	...	...	...	...	...	...
„ 19	...	...	...	...	...	...	...	...
„ 20	...	...	2,000,000	...	...	...	...	...
Totals,	65,940,000	12,840,000	53,600,000					

TABLE II.—Showing particulars in connection with the Distribution of Fry.

Date.	Locality.	Temp. of the Water.	Condition of Weather.	Number of Fry Planted.
March 16	About three miles off Aberdeen Bay.	5·4°	...	4,000,000
„ 20	Three miles off Girdleness.	...	Fair.	8,800,000
„ 26	Off Aberdeen Bay, between three and four miles.	5·3°	...	4,800,000
April 1	In Aberdeen Bay, three and a half miles off.	...	...	4,000,000
„ 6	Off Fraserburgh, two miles off Lighthouse.	5·6°	...	6,000,000
„ 15	Off Fraserburgh, outside the breakwater.	...	Sea rough.	8,000,000
„ 20	About two miles off Aberdeen.	5·9°	...	4,400,000
„ 30	About three miles off Aberdeen.	...	...	7,300,000
May 7	Three and a half miles off Girdleness.	6·2°	...	5,500,000
„ 14	About three and a half miles off Aberdeen Bay.	7·3°	...	4,800,000
„ 20	Fraserburgh, about two and a half miles off.	7·1°	Wind light.	2,000,000

VI.—ON THE POST-LARVAL AND EARLY YOUNG STAGES OF THE WITCH (*PLEURONECTES CYNOGLOSSUS*, LINN.).

By H. CHAS. WILLIAMSON, M.A., D.Sc., Marine Laboratory, Aberdeen. (Plate XVI.)

A very complete series of post-larval and young witches has been collected by Dr. Fulton and these he has handed to me for description.

This form is especially interesting in that it has a very long post-larval period; it reaches a large size before it takes up a bottom habitat, *i.e.* before its transformation from a bilaterally symmetrical fish to a flat-fish.

Drawings of eight post-larval and two young stages are shown in Plate XVI. An extended and detailed description is not necessary, as these serve sufficiently to indicate the general form and the arrangement of the black pigmentation so far as the latter has survived preservation. All of the specimens had been preserved in a solution of formaline in seawater.

Cunningham* was the first to observe the larva of the witch, and his description may be here incorporated. He says—"The larva is not different from that of the other species of *Pleuronectes*; its length is 3.9mm.; there is no pigment in the eye; a number of very minute points are scattered down the sides." About 48 hours after hatching, "the length is now increased to 5.9mm. . . . ; the median fin-fold is much wider; the eye is slightly pigmented, and pigment is largely developed in the skin of the body; the cutaneous chromatophores form five well-marked transverse stripes arranged in longitudinal series along the sides, three of them on the tail, are in the region of the rectum, and one about the pectoral fin."

Holt† gives a more detailed account of the larva and early post-larva. The additional particulars which he furnishes are the following:—"The larva, hatched from an egg captured in the sea, "had pigment of a pale chrome colour by reflected light, and of a dark yellow by transmitted light. This extended over the head, eye, and throughout the trunk and free caudal region, and over the yolk In the next stage black pigment is associated with the yellow, and also appears independently along the margin of the dorsal fin. In a specimen, two days old, hatched from artificially fertilized eggs the length is 5.5mm. We now find a change in the arrangement of the pigment, which is broken up into three distinct bars in the post-anal region. Moreover, the yellow pigment now exhibits a greenish colour by transmitted light."

A drawing of an early post-larval stage (derived from artificially fertilized eggs) ten days after hatching accompanies the following description:—"The eyes are black, with a bluish lustre; the lower jaw is very prominent, the pectorals very large, the otocysts large. The post-anal region is very slender, especially the part ventral to the notochord; the latter is very stout. The urocyst is larger than before. A ventral patch of black chromatophores has appeared midway between each post-anal pigment bar. The most anterior bar, that in the region of the pectoral fins, has lost its distinction. Pigment is absent from the dorsal fin in this region, whilst there has taken place a considerable development of pigment in the lower jaw and anterior ventral region; the coloured pigment

* *Trans. Roy. Soc. Edinburgh*, xxxiii., Pt. I., 1887.

† *Sc. Trans. Roy. Dublin Society* (2), iv., 1893.

is now orange by transmitted light, except in the median fin, where it is brown" (Holt).

Previous to the publication of the paper just referred to, Petersen* had described a post-larval pleuronectid measuring 32mm. in length. He considered it to be a Halibut (*Hippoglossus vulgaris*). Kyle† and Holt and Byrne‡ have recently described post-larval stages of the witch, and these agree closely with Petersen's form, which is apparently really a witch. It has, moreover, the spinous armature of the operculum to which Holt and Byrne draw special attention.§ The fin-ray formulæ for these specimens were as follows:—Petersen's—Dorsal, *ca*, 104; Anal, 88; Caudal, 82. Kyle's specimens (two in number)—Dorsal, 103 (105); Anal, 83, 85; Caudal, 18. Holt and Byrne—Dorsal, 108; Anal, 95.

The post-larval witch is a characteristic form which cannot be confounded with any other known species. Its main characters are its long and narrow post-anal body; the well-marked triple-bar arrangement of pigment on the same; the prominent head and snout, and its extended transformation period. Kyle in this connection says, in referring to the two examples, 12 and 14mm. long respectively, described by him, that their "most striking features, in addition to their length and relative thinness, are the long head, the projecting snout, with the deep depression over the eyes, and the early stage of metamorphosis." In Dr. Fulton's collection the largest post-larval (*i.e.* pelagic) witch measures 40mm., while the smallest young witch (*i.e.* transformed) measures 44mm. Holt describes one of the latter which measured 42mm.

The only other pleuronectid of our waters which approaches the witch in having a lengthy post-larval period is the Lemon Sole (*Pleuronectes microcephalus*). Post-larvæ of this form have been found measuring 27mm. (Holt), but the general shape of the pelagic stages of this species is very different from that of the witch; the outline of the former is oval, whereas that of the latter is elongated.

The witches from which the drawings were made exhibited black pigment only. The pigment other than black has disappeared since they were preserved; and in some cases the black pigment has faded considerably. This probably accounts for the fact that some variation on the pigmentation is found in the forms described, especially as regards the marginal fin. The outer edge of the marginal fin was, moreover, sometimes frayed, and in consequence the presence of pigment there was not in these cases determined.

It is hoped that the sketches here supplied will aid in the diagnosis of preserved examples. A number of the drawings are of natural size; the majority are enlarged. It is sufficient to note that the post-larval characters are constant; the general form, which is more readily indicated by the sketches than by a word-picture, is, when taken along with the bar arrangement, sufficient to indicate the species. A brief note will be given of each of the stages illustrated.

The first (Fig. 1a) is an early post-larval example, measuring in total length 5.2mm., in greatest breadth .75mm. It has the typical pleuronectid form, *viz.* a short abdomen and a long post-anal region. The marginal fin shows no trace of fin-rays; the caudal fin is still diphyccercal. The pigment is well marked. At the point of the mandible there are a few black pigment spots, and in the pectoral region there is a ventral group of spots. On the hind dorsal area of the abdomen a group of large chromatophores is visible, and along the keel of the abdomen there is a

* Report of the Danish Biological Station, iv., 1893.

† Journal of the Marine Biological Association, vol. vi., No. 4, Dec. 1903.

‡ Report on the Sea and Inland Fisheries of Ireland, 1901, Pt. II., Dublin, 1903.

§ Dr. Petersen has informed me that he is satisfied that the form is a witch.

row of similar pigment corpuscles. The eyes are black. The post-anal region is marked by three main transverse bars of chromatophores; they are equi-distant from one another. Each bar consists of a dorsal and a ventral moiety. The hindmost is in the region of the future caudal fin, and is large. Between the bars there are three pigment groups situated ventrally on the edge of the muscle-segments; they may be termed secondary groups, in contradistinction to the main broad bars. Of the post-anal pigment groups just mentioned, the hind main bar alone extends on to the marginal fin. Only one pigment spot was, in addition, found on the marginal fin; it was situated on the ventral fin. A ventral view of this post-larva is shown in Fig. 1b.

In Fig. 2 a specimen similar in size to one of those described by Kyle is reproduced. It measures 12.5mm. in length, and in greatest breadth reaches about 3mm. A greater amount of pigment is found in this individual than in the preceding. Along the ventral edge of the muscle-segments in the post-anal region a few more intermediate or secondary pigment spots are seen, and some pigment was made out on the ventral marginal fin in large and small spots. Anterior to the anus the condition of the preceding specimen holds. The caudal pigment is now diffuse; the caudal fin-rays are being laid down and the tail region is becoming heterocercal. The rudiments of the interspinous bones are indicated by a somewhat opaque part of the marginal fin, next the muscle-segments.

The interspinous bones, still very small, are to be made out in the next figure (3), a drawing of a post-larva measuring 14mm. in length and 5mm. in greatest breadth. In this specimen the large pigment corpuscles on the hind part of the optic lobes were prominent. A natural-size sketch of this post-larva is given in Fig. 9.

A witch 18mm. in length is reproduced in Fig. 4. The fin-rays are now almost completely formed, and the tail is nearly homocercal in character. A row of small pigment spots along the junction of the ventral interspinous bones and the fin-rays is made out.

In Fig. 5 all the interspinous bones and the fin-rays are formed. This example is of the same size as the specimen recorded by Holt and Byrne. In length it measures 25mm., in greatest breadth it reaches 7.5mm. The fin-ray formula is—Dorsal, about 110: Anal, about 95; Caudal, 22.

Fig. 7a is an enlarged drawing of a witch measuring 34mm. In it the pigment was not very prominent; it had probably faded.

A post-larval form, measuring 38mm., is shown in Fig. 12. Transformation is not yet completed. A drawing of the left side of the head of this example appears in Fig. 8.

A completely metamorphosed witch, measuring 44mm., is reproduced in Fig. 13. Holt described one which was a little smaller, viz. 42mm.

The migration of the left eye to the right side of the fish is a slow process. In the fish measuring 25mm. it has moved to a noticeable extent. It then appears a little above the ridge, when the fish is viewed from the right side (Fig. 5). In the large post-larva, 38mm. (Fig. 12), the eye is on the ridge; in another, measuring 40mm., the migration was not completed (Figs. 6a and 6b).

Dr. Fulton examined the last-mentioned specimen (40mm. long) shortly after it was killed in formaline. He found that the only pigment then visible was black. It was distributed as follows:—On the snout and jaw there was a collection of little specks; on the front of the lower jaw a like collection. A group of spots was present on the optic lobes, while a broad band of spots was conspicuous on the hind part of the abdomen. On the median line there were, on the post-anal body, six equi-distant pigment patches. The dorsal interspinous region showed eight fainter patches, while five or six similar patches were seen on the ventral interspinous region.

During the post-larval period the pigment on the two sides of the body remains practically identical. It is only in the larger specimens, *e.g.* 38mm., that it is possible to detect a lighter shade of pigment on the left side than on the right.

With the transformation, however, a very marked difference is noted (Fig. 13). The fish itself becomes more opaque, and its upper surface (the previous right side), shows a large quantity of pigment. Posterior to the anus there are on the upper surface seven broad patches across the median line of the body; on the dorsal fin there are five broad patches with intermediate smaller patches, and on the ventral fin three broad patches with smaller intermediate groups. The under or blind side, however, retains the post-larval pigmentation; in this case it resembled that found in the post-larva measuring 38mm. (Fig. 2).

Holt and Byrne draw attention to the presence of spines on the operculum of the post-larvæ. I have found this spinous armature in the example measuring 12.5mm. (Fig. 2). In the preceding specimen, 5.2mm. (Fig. 1), it was not made out. It was found in all the succeeding post-larval witches, and the spines were equally developed on both sides of the body. The sketches indicate with approximate accuracy the number and arrangement of them.

In the metamorphosed example, 44mm. long (Fig. 13), teeth were found on the operculum. Two large teeth projected from the posterior part of the operculum, and dorsal to these three were two (or three) other similar teeth. They were equally developed on both sides of the fish.

No spines were made out on the operculum of either side in the young witch measuring 59mm. in length.

Small teeth (in the jaws) were made out in the smallest member of the series, and they were present in all the other post-larval stages. They are not numerous. Teeth were not seen in the smaller bottom form.

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EXPLANATION OF PLATE XVI.

N.B.—No attempt has been made in the drawings to insert the proper number of interspinous bones and fin rays.

Fig. 1a. Post-larval, <i>Pleuronectes cynoglossus</i> , 5.2mm. long ; .75mm.		greatest breadth, . . .	× ca 19
Fig. 1b.	Do.,	do.,	do., ventral view.
Fig. 2.	Do.,	do.,	12.5mm. long ; 3mm. greatest breadth, . . .
Fig. 3.	Do.,	do.,	14mm. long ; 3mm. greatest breadth, . . .
Fig. 4.	Do.,	do.,	18mm. long ; 5mm. greatest breadth, . . .
Fig. 5.	Do.,	do.,	25mm. long ; 7.5mm. greatest breadth, . . .
Fig. 6a.	Head of post-larval, do.,	40mm. long ; right side, .	× ca 6
Fig. 6b.	Do.,	do.,	40mm. long ; left side, .
Fig. 7.	Post-larval, do.,	34mm. long ; 13mm. greatest breadth, . . .	× ca 6
Fig. 8.	Do.,	do.,	38mm. long : left side, .
Fig. 9.	Do.,	do.,	14mm. long, natural size.
Fig. 10.	Do.,	do.,	28mm. long, do.
Fig. 11.	Do.,	do.,	34mm. long, do.
Fig. 12.	Do.,	do.,	38mm. long, do.
Fig. 13.	Young, do.,	44mm. long, do.	
Fig. 14.	Do.,	do.,	59mm. long, do.

VII.—ON SOME PARASITES OF FISHES NEW TO THE SCOT-
TISH MARINE FAUNA.

By THOMAS SCOTT, I.I.D., F.L.S.

Plate XVII.

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PRELIMINARY NOTE.

Some time ago Dr Fulton, Scientific Superintendent to the Fishery Board, kindly handed to me for examination a specimen of *Trygon pastinaca*, Lin., which had been captured in the Dornoch Firth on October 22, 1903. This specimen measured about 14½ inches across the pectoral fins and about 24½ inches from the nose to the extremity of the very slender tail; it was thus not more than about the average size of this kind of fish, yet it yielded on examination no fewer than four different species of ectozoa. Two of these species belong to the Copepoda and two to the Trematoda, and only one of them, viz., *Brachiella pastinacæ*, van Beneden, appears to have been previously described. Descriptions and drawings of these apparently new forms are given here.

Moreover, while examining some organisms set aside from former collections, I found a specimen of *Lernæa lusci*, Bassett-Smith, obtained off Aberdeen in January, 1902; as this parasite has not before been recorded from Scottish waters, I have had a short description, with drawings of it, prepared for this paper.

I have further to state that at the end of this paper will be found a description and drawing of a very curious Natural History group consisting of a larval fish, somewhat emaciated, and two small Crustaceans, which appear to be attacking the fish; for this interesting specimen I am indebted to my friend and colleague, Dr Henry Charles Williamson.

The drawings have been prepared by my son, Mr A. Scott, A.L.S.

I propose to describe the various organisms mentioned in the order in which they are referred to above.

PART I.—COPEPODA PARASITA.

FAM. DICHELESTIDÆ.

Genus *Eulactylina*, van Beneden (1853).

Eulactylina minuta, T. Scott. Pl. xvii., figs. 111.

Description of the Female.—The length of the specimen represented by the drawing (fig.1), measuring from the forehead to the end of the furcal

joints, is about 1.1 mm. (about $\frac{1}{23}$ of an inch), but that represented by figure 2 is slightly larger, and measures about 1.4 mm. The segments, especially along their dorsal aspect, are rough with minute scattered spines. The body is slender, as in the species previously described, but the fourth and fifth segments are rather more dilated than the others. The cephalosome is about equal in length to that of the first two segments of the metasome combined. The first segment of the metasome is a small one, while the next two are each rather longer and stouter than the one immediately preceding; the last segment of the metasome is considerably smaller than the third one. The segmentation of the urosome (abdomen) somewhat resembles that of *Eudactylina similis*, A. Scott.

The antennules, which are short and stout, are apparently five-jointed, as in those of the species referred to, and their armature is also similar to that of *Eudactylina similis*, but, on the other hand, there is a distinct difference in the proportional lengths of the joints,—the third being longer than the second joint and the fourth scarcely twice as long as the ultimate one (fig. 3).

The antennæ, which are moderately elongated, have a general resemblance in their form and structure to those of the other described species; but the second joint, which is about as long as the third, is produced on the inner aspect and near the distal end so as to form a single stout and prominent spine, and a single powerful hook-like spine with a thickened base carrying a few small setæ is articulated to the extremity of the third joint (fig. 4).

The mandibles and maxillæ do not present any marked difference from those of *Eudactylina acuta*, van Beneden.

The first maxillipeds, which resemble the same appendages in *Eudactylina similis*, are armed with a moderately stout terminal claw, and the end joint is furnished with a row of minute coarse denticles along the inner edge (fig. 5).

The second maxillipeds are large and strong and form powerful chelæ; they are somewhat similar in structure to those of *Eudactylina similis*, but the extremity of the claw which impinges against the lower spoon-like process has the stout apical tooth with a rounded hood-like covering (fig. 6).

In the first pair of thoracic feet both branches are two-jointed, and both are moderately stout; the inner branches are sparingly fringed with minute setæ, and armed with two apical spines of unequal length; the outer branches, which are rather shorter than the inner, are each furnished with a fringe of minute setæ on the outer margin of the first joint, while the end joint bears several spines round its outer margin and apex; the inner spine is of moderate length, but the others are small (fig. 7).

The structure of the second pair has a general resemblance to that of the same pair in *Eudactylina similis* and *E. acuta*. The inner branches, which are distinctly three-jointed, are considerably smaller than the outer ones, the first joint bears a longitudinal row of small spines on its inner aspect, while the end joint carries two apical spines of moderate but unequal length. The outer branches are stout and elongated, and, like the inner ones, appear to consist of three joints, but the articulation between the first and second joints is apparently nearly obsolete; two short spines which have their bases dilated spring from the outer margin and near the distal end of the elongated first joint; the third joint, which is short and rounded at the extremity, is provided with a single and moderately stout subterminal spine, as shown in the drawing (fig. 8).

The third and fourth pairs are nearly alike, and resemble the same two pairs in *Eudactylina similis*, except that the inner branches are furnished with a number of scattered spinules on their outer aspect; the outer branches are each of them rounded at the extremity, and provided with

a single elongated terminal seta, there are a few spines on the outer margins of the second and third joints, while the first joint bears a fringe of minute spines along its outer edge (fig. 9).

The fifth pair, which are broadly foliaceous and resemble in their general outline the same appendages in *Eudactylina acuta*, van Beneden, are furnished with several transverse rows of minute spines and three apical setæ (fig. 10).

The furcal joints, which are rather longer than the last abdominal segment, are each of them armed with two terminal spines—a stout one at the apex and a somewhat smaller one on the outer edge, as shown in the figure; a small seta springs also from near the middle of the outer margin (fig. 11).

Habitat.—On the gills of a specimen of the “Sting Ray,” *Trygon pastinaca*, Linn., captured in the Dornoch Firth on October 22, 1903. No males of the *Eudactylina* were observed. The fish, as already stated, measured about $14\frac{1}{2}$ inches across the pectoral fins, while its length from the snout to the extremity of the tail is about $24\frac{1}{2}$ inches.

Remarks.—This *Eudactylina* appears to differ from previously described species by its smaller size—being little more than half the length of the smallest hitherto recorded, and from its being found on a different host. But there are also structural differences which separate it from other forms. I will recapitulate one or two of these: it differs in the proportional lengths of the joints of the antennules, in the armature of the antennæ, in the armature of the first maxillipeds, in the structure of the second pair of thoracic feet, and in the proportional lengths of the segments of the thorax.

Though a number of specimens were obtained, only a small proportion of them were in good condition for dissection.

Eudactylina acuta, Van Beneden.

1853. *Eudactylina acuta*, Van Beneden, Bull. Acad. Roy. Belg., vol. xx., pt. 1, p. 235; Mem. Acad. Roy. Belg. (1861), p. 150, Pl. xxv.

In my notes on the parasites of fishes in Part III. of the Twentieth Annual Report of the Fishery Board for Scotland (published October 2nd, 1902), I describe the occurrence of *Eudactylina acuta* on the gills of an Angel-fish, *Rhina squatina* (Lin.), captured in January 1902 about eight or nine miles south-east from Buchan Ness, and the description of the parasite is illustrated by a series of drawings. My son had already obtained the same *Eudactylina* on the gills of Angel-fishes captured in the Irish Sea, but there did not appear to have been any previous record of it from Scotland.

Through the kindness of Mr. Robert Duthie, Fishery Officer—presently stationed at Girvan, Ayrshire—I am enabled to record this interesting parasite for the second time from Scottish waters, which, like the specimens previously referred to, was found on the gills of an Angel-fish. This fish, which was captured by turbot-net fishermen in the seaward part of the Clyde estuary and landed at Girvan on May 25th (1904), was secured by Mr. Duthie, who kindly forwarded it to me for examination. The fish was an immature female, and measured two feet nine and a-half inches (nearly 83 centimetres) from the front of the head to the extremity of the caudal fin. This *Eudactylina* is an addition to the parasitic Copepod-fauna of the Clyde.

Lernæa lusci, Bassett-Smith. Pl. xvii., figs. 12 and 13.

1896. *Lernæa lusci*, Bassett-Smith, Ann. and Mag. Nat. Hist. (6), vol. xviii., p. 13, pl. iv., fig. 6.

The form described under this name is considerably smaller than the

more common *Lernæa branchialis*, and hitherto it appears only to have been observed on the gills of the Brassie or Whiting Pout (*Gadus luscus*, Linn.). The specimen I have to record was obtained on the gills of a Brassie captured about ten miles off Aberdeen on January 16, 1901. This parasite measures a little over half an inch from the head to the end of the genital segment. The neck is slender and short, and the appendages of the cephalon are moderately developed. Dr. Bassett-Smith describes the posterior appendage as being sometimes as long as the neck, which is also characteristic of the specimen now recorded (fig. 13). The genital segment is considerably dilated and strongly sigmoid, except at the posterior end where, in marked contrast to *Lernæa branchialis*, it is only slightly curved; the twisted egg sacs are proportionally not so slender as in that species.

Lernæa lusci does not appear to have hitherto been recorded from Scottish waters, having been probably regarded as a form of *L. branchialis*. Figure 12 shows the specimen attached to the gill-arch of the fish.

Brachiella pastinacæ, Van Beneden.

1851. *Brachiella pastinacæ*, Van Beneden, Ann. des. Sci. Nat., 3rd ser., t. xvi., p. 118, pl. iv., figs. 8, 9.

Two specimens of this *Brachiella* were obtained in the nasal fossæ of the *Trygon* in which the *Eudactylina* just described was found. One specimen occurred in each of the two fossæ. These two specimens which were posted to the artist along with a few other things in order to have drawings of them prepared, failed to reach their destination, and I am therefore unable to furnish figures of this species.

PART II.—TREMATODA.

FAM. TRISTOMATIDÆ.

Thaumatocotyle concinna, gen. et. sp. nov. Pl. xvii., fig. 15.

A large sucker-disc, so characteristic of several of the Trematoda, is attached to the distal end of the body by a very short stalk which is apparently flexible. The sucker is nearly circular in outline, and its ventral surface is divided into thirteen marginal compartments which are separated from each other by narrow muscular bands; the compartment at the lower end of the sucker is larger than any of the other twelve and is of the form of an equilateral triangle, the blunted apex of which is directed inwards and reaches fully half way toward the centre of the sucker; the other twelve marginal compartments are of nearly equal size and are sub-quadrate in form, as shown in the drawing (fig. 15). Two moderately slender rods spring from two adjacent muscular bands near the centre of the disc, and extending to the circumference of the sucker terminate in little hook-like processes—one on each side of the lower triangular compartment.

The anterior end, which terminates somewhat abruptly and has a broadly triangular outline, is bifurcated in the middle. On the ventral aspect, close to the margin on each side of the fork and extending from it to the outer angle, there are arranged three small discs which may probably function as suckers.

The length of the specimen represented by the figure is about 3 millimetres (nearly $\frac{1}{8}$ of an inch), while the breadth at the widest part is equal to about one fifth of the length; the body is flattened and in some specimens nearly transparent, so that the internal structure may to some extent be discovered.

This Trematode does not agree with any genus or species known to me.

Habitat.—In the nasal fossæ of *Trygon pastinaca*, captured in Dornoch Firth, October 1903.

Heterocotyle pastinacæ, gen. et sp. nov. Pl. xvii., fig. 14.

Several specimens of the Trematode described under this name were obtained on the same *Trygon pastinaca* with the form just recorded, but they were found not in the nasal fossæ but on the gills along with *Eudactylina minuta* described in the first part of this paper.

In this Trematode the posterior sucker is slightly oval in outline—the transverse diameter being greater than that which is longitudinal in the proportion of about 13 to 11. The edge of the sucker is indistinctly crenate, and its ventral surface is divided into eight compartments, which extend from the circumference to near the middle, where they are interrupted by a small diamond-shaped space representing the point of attachment of the sucker to the body. The two lowest compartments are of a slightly larger size than the four upper ones, but the compartment on each side is about double the size of the one immediately above. Moreover, these side compartments, together with the two lower ones situated between them, are each sub-divided into two portions by a circular line, as shown in the drawing (fig. 14). About the middle of the band which divides each large lateral compartment from the lower one, there is attached a short rod that terminates in a strong hook.

The body is of a narrow ovate form and is considerably depressed; the greatest width is equal to nearly three and a half times the length; the total length of the specimen represented by the drawing is only 1.44 mm. (about $\frac{2}{35}$ of an inch). The anterior end is narrowly truncate, and is without any lateral appendages, as in *Phyllonella* or *Placunella*, which it otherwise resembles.

Besides the occurrence of the four different kinds of parasites from the Sting Ray mentioned here, Prof. van Beneden has obtained on specimens of the same species of fish taken on the coasts of Belgium, not only the *Brachiella pastinacæ*—which he found both in the nasal fossæ and on the gills—but also *Lerneopoda galei* and *Ergasilina robusta*; the first he obtained in the nasal fossæ and the other on the gills. The same writer also records finding five different kinds of Cestoids in the intestines of *Trygon*.*

PART III.

NOTE ON A POST-LARVAL FISH ATTACKED BY PODON LEUCKARTI.

Plate XVII.—Fig. 16.

It is fairly well known to students of the Entomostraca that these organisms live to some extent on animal as well as on vegetable matter, and also that they do not always confine themselves to decaying substances, but that living specimens, if small enough and in a weak or sickly condition, are not exempted from being attacked by them. When examining a gathering of living Entomostraca in which Ostracoda are frequent, we may occasionally observe a number of these minute Crustaceans crowding round some object of general interest, and, when the reason for the crowding is investigated, find that they are busy feeding on a dead or dying companion.

* Les Poissons des côtes de Belgique leurs Parasites et leurs Commenceaux, pp. 14, 15 (1870).

But although such incidents are not of rare occurrence among the Entomostraca, the example to which I would direct attention, where a post-larval fish is apparently being attacked by two members of the family Polyphemedæ, is somewhat unusual. Larval and post-larval fishes have no doubt many enemies, among which may be included other fishes as well, and it has also been shown that even the harmless-looking *Sagittæ* feed upon such larvæ,† but this is the first time I have observed Entomostraca presumably attacking a post-larval fish in the manner shown by the drawing.

As stated in the preliminary note, I am indebted to Dr. Williamson for this interesting specimen. The fish, he tells me, is a Pleuronectid—probably *Pleuronectes platessa*—but its emaciated condition made its correct identification somewhat doubtful. That these Crustaceans have become accidentally attached to the specimen is hardly likely, for the position they occupy and the firm hold they have of the fish, evidenced by their adhering while extraneous matter was being brushed off, and by their continuing to adhere firmly though subjected to a good deal of tossing about, does not favour such an explanation, but tends rather to support the opinion that they have intentionally seized hold of the young Pleuronectid, but whether for the purpose of attacking or merely for resting I am not prepared to say. The specimen is, however, sufficiently interesting to be recorded here. The fish was observed in a tow-net gathering collected last year and supposed to be from the North Sea. The two Crustaceans belong to the same species, viz., *Podon leuckarti*.

* Annals of Scottish Natural History, April, 1892, p. 142.

DESCRIPTION OF THE PLATES.

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VIII.—ICHTHYOLOGICAL NOTES.

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Scientific Investigations.

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THE YOUNG OF THE CONGER (*Leptocephalus*).

Two specimens of the young of the conger eel were caught in the Moray Frth by means of the small-meshed net around the otter trawl, which has been so productive of rare forms, and as such specimens are very rarely obtained in British seas, and they differ from one another in age and characters, I have thought it desirable to give a description and figures of them here.

The first specimen (Fig. 1) was obtained on 27th December on Smith Bank, a well-known fishing ground off the coast of Caithness, in 28 fathoms of water. It was not recognised at the time among the other fishes caught and the lot were preserved in formaldehyde and taken to the marine laboratory at the Bay of Nigg. It was only later, when the material was being worked up, that the specimen was discovered. With the exception of a slight abrasion on the posterior half it was in good condition; the imperfection was probably due to the fish having been caught by doubling as it passed through the mesh of the net. On examination some weeks after it was caught it was found to be translucent, with a whitish opacity, the perfect transparency of the living form having been affected by the preservative. It was quite soft and flexible, resembling a tapeworm in these respects, as well as in its extremely flattened form. In extreme length it measured 145mm., (5¾ inches), and it is therefore among the largest of the specimens recorded. Its weight, after the superfluous water had been removed, was only 0·61 grammes, and its volume was 1·1 cubic centimetres as nearly as could be determined. Its bulk in proportion to its length, as will be seen below, was thus very much under that of the other older but shorter specimen.

The extreme dorso-ventral height of the body was 13·5mm., and it was broadest from about 70 to 95mm. from the head; the height just behind the head was 7mm., or about half of the other. The thickness of the body was difficult to determine; it was much thicker behind the head, where it measured about 2mm., and from this point to the posterior extremity it gradually diminished, the greater part of it being rather under than over 1mm. in thickness. The length of the head from the tip of the snout to the gill-cleft measured 10mm., and its height at the eyes was 5mm., the breadth being 3mm. just behind the

eyes. The eyes were relatively large, measuring 2.5mm. in diameter (they are represented as rather too large in the enlarged figure, and as a little too small in the other figure); the anterior edge is situated about 3mm. from the tip of the snout. The snout is blunt and obtuse and rounded, and longer than the lower jaw, which is more pointed. The cleft of the mouth ends rather behind the middle of the eye, and each jaw is armed with a series of somewhat long, fine, slender teeth, those in front being the longest; of these, 34 were made out in the lower jaw and 30 in the upper.

The pectoral fins, placed immediately behind the gill-opening, were small and delicate, measuring about 3.5mm. in length.

With regard to the pigment, there were two minute specks of black on the lower part of the gill-cover on the left side and four similar specks on the corresponding position on the other side. A linear series of black specks runs along each side of the ventral margin, beginning about 11mm. behind the pectoral fin; they are most distinct in the anterior portion but are continuous to the tail, and in the posterior part they are much more minute, numerous, and crowded, giving the appearance of a very fine black line. Along the lateral line there is a single linear series of corresponding chromatophores, of which 35 were counted, and beginning about 35mm. behind the head; they are usually situated at the junction of myotomes, and are most numerous towards the tail. No other pigment specks were observed.

Of the myotomes—which are very distinct except at the tail—I counted 142, but, as stated, those at the posterior extremity are indistinct.

The second specimen (Fig. 2) was of a different kind in several respects. It was taken in 24 fathoms, also in the Moray Firth but south of Smith Bank, on 12th February. In shape it is vermiform rather than tænioid, and appears to correspond to the *L. punctatus* of Kaup, and which has been shown by Grassi and Calandruccio to be the stage from which the perfect conger is directly developed. It measures 123mm. ($4\frac{7}{8}$ inches) in extreme length, and weighed, after the superfluous water was removed by blotting paper, 1.675 grammes, its volume being 1.8cm. It will be seen by comparing these figures with those referring to the other specimen that the reduction in length is accompanied by a considerable increase in bulk, since the shorter specimen weighed over 1 gramme more than the other, its weight being nearly three times greater. The volume, as stated, did not increase in the same proportion; the discrepancy is perhaps due to the tissues of the younger being less solid, perhaps to defect in the determination of the volume.

The extreme breadth of this specimen is 10.5mm. and its thickness 3mm. Its thickness is maintained in a fairly uniform way for the first two thirds of the length of the body, after which it diminishes rapidly. The distance from the tip of the snout to the commencement of the dorsal fin is 44mm. and from the same point to the anus 55mm. The head is 9mm. in length, 4.5mm. high, and 3.5mm. broad, and the top is more rounded than in the younger specimen. The eye is somewhat smaller, measuring 2mm. in diameter and placed 2.5mm. from the end of the snout. The lower jaw is shorter than the snout, but not to the extent represented in fig. 2b. Teeth, so conspicuous a feature in the younger specimen, could not be made out. The pectorals were more developed, being longer and, especially, broader. Of the myotomes, not so distinct as in the other form, 141 were counted. The black chromatophores were arranged as in the younger specimen, but none were observed on the head. Those along the lateral line are more conspicuous than those placed along the ventral margin, of which there are 26 in front of the anus, and they are much more numerous behind, being crowded together, as in the first specimen, towards the tail.

The literature dealing with these young forms need not be given here, as Cunningham has given a very full account of it in some of his papers,* and he has described a specimen of *Leptocephalus Morrisii* which he obtained at Plymouth in June, 1895.† Besides the classical papers of Grassi and Calandruccio, reference may be made to two papers, one by Eigenmann on "The Egg and Development of the Conger Eel," and the other by the same author and C. H. Kennedy, on the "Leptocephalus of the American Eel and other American Leptocephali," both published in 1901.‡

A LARVAL *Fierasfer*.

On 8th October last year a larval *Fierasfer* was taken in a tow-net used on board a fishing boat at a distance of about 185 miles E. by N. of Aberdeen; the net was used between the surface and twenty fathoms, the depth at the place being between fifty and sixty fathoms. (Pl. XVIII., fig. 3, 3a).

The specimen measured 64mm. ($2\frac{1}{2}$ inches) in length and exhibits the slender form characteristic of the genus; the yolk, as indicated in the figure, forms a considerable mass. The remarkably elongated first dorsal ray was apparently damaged, but enough of it is left to show the presence of the skinny lobes with which it is provided.

Fierasfer is remarkable for its habit in the adult condition of living within Holothurians in a condition of commensalism, but it would appear that its larval pelagic life is one of considerable duration. It is an extremely rare fish, and even Emery, who has written the classical monograph on it,§ was able to obtain only a few specimens.

Outside the Mediterranean, specimens have rarely been obtained. According to Couch, Edwards found six specimens, between 6 and 7cm. long, in March, 1863, on a sandy bottom off the coast of Banff, but the record stands in need of confirmation and is passed over by Day. The latter author mentions only two examples of *F. dentatus*, both got on the south coast of Ireland, one in 1836 and the other in 1852, and there does not appear to be any other good British record of its occurrence.

Only other three specimens appear to be recorded for the north of Europe. One was taken by a fisherman in from 100-200 fathoms on the Jutland Reef, to the west of the Scaw—and therefore not a great distance from the locality where the specimen here recorded was obtained—and it is now in the Royal Museum at Stockholm. The second specimen was got near Stavanger in 1881, and was described by Collet; it is in the Bergen Museum.|| The third was a specimen of *F. acus*, obtained by H.M.S. *Triton* in the Farøe Channel, on 9th August, 1882, close to the surface. It measured 104mm. in length, and has been described by Günther.¶

THE STING-RAY (*Trygon pastinaca*).

On the 22nd October a specimen of the sting-ray was taken in the trawl by one of the trawlers engaged in scientific work in the Dornoch Firth in from 8 - 13 fathoms. It was a female, measuring in extreme length 63·0cm., and in extreme breadth 37·5cm. It is noteworthy that

**Journ. Marine Biol. Assoc.*, vol. iii, p. 281; vol. ii, p. 36.

†*Ibid.*, iv, p. 74.

‡*Bull. U. S. Fish Comm. for 1901*, pp. 37-81.

§"Fierasfer. Studi intorno alla sistematica, l'anatomia e la biologia delle specie mediterranee di questo genere." *Atti R. Accad. d. Lincei*, vii., 1879-80.

|| *Christian. Vidensk. Forhandl.* 1882, No. 19.

¶ "Report on the Pelagic Fishes collected by H.M.S. 'Challenger' during the years 1873-1876," page 27, 1899.

the torpedo described in the *Nineteenth Annual Report** was caught near the same place. On this specimen Dr. Scott found some new and interesting parasites (*see* p. 275.)

This fish is said by Day to be not uncommon off the mouth of the Thames and along the south coast, and Dr. Murie states that on the coast of Kent and at Burnham specimens from 1½ to 2 feet are not uncommon, while in the estuary of the Thames it is not abundant and only small specimens are found.† Holt refers to two small specimens trawled off Plymouth, and several taken on the trawling grounds off Salcombe; and he says the fish is well known to the local fishermen and hardly deserves special mention as a rare fish in that district.‡

It is, however, a very rare fish in Scottish waters. Parnell met with only one example, which was caught in a salmon-net in the Firth of Forth,§ and Mr Eagle Clarke, who has brought together all the descriptions of rare species of the Firth of Forth since the time of Parnell, met with only one specimen which he examined in 1897, and which was caught off the Isle of May, and it is the only instance he knows of since Parnell's record.|| It does not appear, either, that the indefatigable Edwards of Banff ever came across a specimen.

It is noteworthy that this species, like the torpedo, usually has the skin smooth and soft; though Day mentions that there are occasionally some tubercles along the middle line of the back in the scapular region. The one is protected by its electric organ and the other by the formidable serrated spine with which its tail is provided, and which is capable of causing dangerous wounds; they thus differ from the ordinary rays in this respect.

THE PILCHARD (*Clupea pilchardus*).

On the 20th June last year a pilchard was taken in a drift-net employed in catching herrings, about 15 miles off Buckie, in the Moray Firth, where it was landed. I am indebted to Mr. Alexander Sutherland, the Fishery Officer of the district, for the record. It measured 8¼ inches in length.

In Scottish waters the pilchard is a very rare fish. Parnell, writing in 1837, says that it was then very rare, although some thirty years before it was common, and in certain localities found in equal abundance with the herring; as no authority is quoted the statement may be based on Parnell's own observations. He says that a few were occasionally taken in the summer months on the Berwick and Dunbar coasts, but that since 1816 no pilchard had been observed in the Firth of Forth. Day also states that pilchards were more than usually abundant at Yarmouth in 1780, 1790, and 1799, but he does not mention his authority.

They are, however, occasionally taken at long intervals. Thus Eagle Clarke states that Mr. Logan records in the "Proceedings of the Royal Physical Society of Edinburgh" (vol. ii., p. 289) that in March, 1861, considerable numbers of young pilchards were brought to the Edinburgh market along with herrings and sprats; they were only caught in large quantities for a few days in March, but they had occurred sparingly with herring during the previous winter months. Dr. Murie¶ says that

* Part III., p. 290.

† "Report on the Sea Fisheries and Fishing Industries of the Thames Estuary," p. 169, Kent and Essex Sea Fisheries Committee, London, 1903.

‡ *Journ. Marine Biol. Assoc.* v., p. 198, 1898.

§ "Fishes of the Firth of Forth," p. 440, 1838.

|| *Annals of Scottish Natural History*, Oct. 1900, p. 215.

¶ *Op. cit.*, p. 104.

a considerable number were taken off Harwich in September, 1868; and a few stragglers are still brought in with the herrings at Yarmouth, according to Patterson in the Zoologist for 1897.

THE FECUNDITY OF THE SPRAT.

Observations on the fecundity of the sprat have been apparently rarely made, no doubt from the rarity of ripe sprats among those caught by fishermen, the only statement on the point, as far as I am aware, being in my paper on the Fecundity of Fishes in the Ninth Annual Report of the Fishery Board.* In their work on British Marine Food Fishes, Professor M'Intosh and Mr. Masterman say that "the mature female appears to carry about 5000 or 5400 eggs, more or less," which agrees generally with what is stated in the paper referred to, but it is not mentioned whether their remark is based on my observations or on others of their own confirming it.

Ripe sprats having been caught in the Moray Firth in the small-meshed net used on board trawlers the opportunity was taken to investigate the point again, the previous observation having been founded on only one specimen, and that not very well preserved. As mentioned elsewhere, it is a striking feature in the ripe sprat that it is impossible to tell from the external appearance that it is ripe. There is no swelling caused by the ovaries or testes as in most other fishes, and on opening the fish the ovaries were found to be very small, although the eggs were mature and nearly mature. The contrast with the ripe herring, for example, is marked, and yet the eggs in the latter are demersal, while most fishes with pelagic eggs have greatly enlarged ovaries and exhibit abdominal tumefaction at the spawning time. It appears, however, that all this is in conformity with the number of eggs spawned by the sprat. The fish which I examined in 1890, referred to above, measured $4\frac{1}{2}$ inches in length, and was found to contain about 1404 large eggs, and about 4000 smaller ones; the ovaries weighing 6.5 grains.

The following are the particulars of five females examined.

	Length.	Weight.	Weight of Ovaries.	Piece Examined.	No. of Eggs.	Total Eggs.
	Mm.	Grammes.	Grammes.	Grammes.		
1	122	12.8	0.38	.032	228	2713
2	120	12.0	0.492	.041	274	3488
3	124	12.8	0.441	.037	158	1880
4	122	10.5	0.458	.058	297	2346
5	120	11.8	0.541	—	147	2484

The eggs enumerated were those which were large and yolked, but there were many smaller, and in point of fact it would be difficult to draw a line anywhere between the large and the small, and to say that so many belong to this spawning season and so many to the next. The average number of eggs in these specimens was 2582, the small unyolked being excluded, which is rather greater than the number given for them in the early paper referred to. On the whole, however, on the assumption that the small eggs develop and become mature during the

* Part III., p. 268.

course of the spawning season, the number stated in the paper may be about right, viz., 5000. The duration of the spawning season is not well known. The floating eggs were procured by the *Garland* from 23rd March to 19th August,* and it so happened that the extreme dates were in the same year, so that the period mentioned, comprising 149 days or very nearly five months, may be taken to represent the extent of the spawning season. How long the individual sprat goes on spawning is not known, but considering that the period embraces the warmest part of the year, and that growth is greater then, it is probable that at least the 5000 eggs are shed. But even in that case, it is evident that the sprat is one of the least fecund of fishes and, so far as known, the least of all among the fishes whose eggs are pelagic. Amid the varied complexities in the life of marine fishes the explanation is not easy to discover. That the comparatively early age at which the sprat may reach maturity is not the sole explanation—though doubtless an important factor—is shown by the fact that the whiting, which reaches maturity in its second year, produces a very much larger number of eggs.

AN ALBINO PLAICE.

Last year a few post-larval plaice were discovered in the hatching apparatus, and among them was a small albino specimen, or one in which the pigment was almost entirely absent. The only pigment present was a few scattered chromatophores along the rays of the dorsal, ventral, and caudal fins, on the anterior part of the head between the eyes, the edge of the lower jaw, and between the jaw and the pectorals, and about a couple of dozen of minute specks scattered over the posterior half of the body, mostly near the tail. The eyes were fully pigmented. The pigment was a dark umber. The body of the little fish was transparent, the bottom of the hatching-box being visible through it. It lived for about a year, and it differed in habit from the other small plaice living with it in that, while they were nearly always on the bottom, it preferred the side of the box, to which it clung, close to the surface of the water. The peritoneal lining of the abdominal cavity shone through the tissues with a metallic bronze appearance.

THE THICKBACK (*Solea variegata*).

Two specimens of this species of sole were taken in the small-meshed net in the Moray Firth—the first on 27th December in 28 fathoms at Smith Bank, and the other on the following day in 30 fathoms off Burghead. They were both females—the first measuring 14·8cm. with the roe well developed, and the second 16·3cm. The latter weighed 38 grammes, the ovaries weighing 1·1 grammes, and the eggs were well advanced, the larger measuring ·84mm. in diameter. It is evident, therefore, that this fish spawns in the Moray Firth, but it is rare.

It is common on the south coast of England, especially (according to Cunningham)† south of the Eddystone, in from 30 to 40 fathoms. Two specimens were taken by Holt during the Irish Survey. It has also been occasionally captured on the west coast of Scotland, Gunther describing two immature specimens caught off Cantyre in 65 fathoms in March 1888,‡ and a few small specimens have been taken by the *Garland* in the Firth of Clyde. Day says that it was met with occasionally off Banff by Edwards, but I have not traced the record.

* Masterman—"A Review of the Work of the 'Garland' in connection with the Pelagic Eggs of the Food Fishes," *Ibid.*, Part III., Fifteenth Report, p. 234.

† "Marketable Marine Fishes" p. 259.

‡ *Proc. Roy. Soc., Edin.* xv., p. 220.



THE GROWTH OF THE HALIBUT.

A specimen of the halibut, which was obtained for me by Mr. Ingram, the Fishery Officer at Aberdeen, may possibly throw some light on the growth of this fish. It was caught at Iceland by hook in the spring, and landed at Aberdeen. It measured 64·0cm. (25 inches) in length, and weighed 2·350 kilogrammes. On the under surface, extending the whole length and breadth of the fish, were certain markings, part of which was plain and part obscure. The following was very clear:—"T. M. 1901," and it was succeeded by what appeared to read "AGLI," but may have been meant to represent "AUGT," or August. The marks were obviously made with a knife, and the curves were angular; the cicatrix was very narrow and linear and attached to the subcutaneous tissue, and I suppose it occupied the same relative position in the surface of the fish at first, the skin growing equally all over.

I am informed by Mr. Ingram that the mate of the vessel which brought in the fish (the *Caspania*) states that in his time it was a common custom for the fishing apprentices at Grimsby to "engrave" their names in this way on small halibut, and then throw them overboard. If the date is authentic, it would show that the growth of the halibut in proportion to the size it attains is not rapid, because it implies that about two years and eight months elapsed after the marking was made, and the fish must at the time have been of a certain size. But a plaice of about the length given would be probably more than six or seven years old at least.

REVERSED ACTION OF THE GILL-COVER IN PLAICE.

It may be worth recording that the plaice in the large pond at the Bay of Nigg Laboratory frequently exhibit a reversal of the usual action of the gill-cover under certain conditions. In the process of respiration fishes take in water by the mouth, and by a process like that of swallowing expel it by the gill-openings. But when the tame plaice in the pond cling to the side at feeding-time, they very commonly push their snout and head for some distance out of the water, and it may then be observed that the water is spouted upwards from their mouth as a little fountain, an inch or so in height. In this case it is evident that the water is drawn in through the gill-openings behind, passes over the gills, and is then expelled by the mouth. The observation has some interest in connection with the known habits of some other fishes.

EXPLANATION OF PLATE.

- Fig. 1. *Leptocephalus Morrisii*, natural size.
 (1a.) Head enlarged, side view.
 (1b.) " " dorsal view.
 Fig. 2. *Leptocephalus punctatus*, natural size.
 (2a.) Head enlarged, side view.
 (2b.) " " dorsal view.
 Fig. 3. *Fierasfer dentatus*, larva, natural size.
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TWENTY-THIRD ANNUAL REPORT.

TO THE MOST HONOURABLE
THE MARQUESS OF LINLITHGOW, K.T., G.C.M.G.,
His Majesty's Secretary for Scotland.

OFFICE OF THE FISHERY BOARD
FOR SCOTLAND,
EDINBURGH, 30th June 1905.

MY LORD MARQUESS,

In continuation of our Twenty-third Annual Report,
we have the honour to submit—

PART III.—SCIENTIFIC INVESTIGATIONS.

GENERAL STATEMENT.

This part of the Twenty-third Annual Report deals with the scientific investigations conducted by the Board in 1904 in connection with the sea fisheries of Scotland, so far as these have been completed, by means of the Parliamentary Vote granted for the purpose.

The scientific work has been carried out and the scientific report prepared under the supervision of Dr. T. Wemyss Fulton, the Scientific Superintendent.

The researches have been made for the most part at the Board's Marine Laboratory at the Bay of Nigg, Aberdeen, which was erected and equipped some years ago. The sea-fish hatchery is also situated at the same place, and a statement as to its operations during the year will be found below. The provision of a suitable boat in connection with the Laboratory would be of much advantage in carrying on the investigations.

The investigations into the condition of the fishing grounds, more particularly in the Moray Firth and Aberdeen Bay, which were begun five years ago by means of steam-trawlers, were continued last year as frequently as circumstances allowed. One of the chief objects of these trawling investigations is to ascertain as far as possible the changes which may occur in the abundance of the

food and other fishes on the grounds visited in different years and at different seasons, but observations are also made on the reproduction of the fishes, their spawning, food, and on various other questions connected with their life-history and habits, and at the same time collections of the plankton, or floating organisms, are obtained, and experiments made with large-meshed and small-meshed nets.

Although the employment of commercial vessels in these investigations is associated with certain inseparable disadvantages, it is possible with the large ship, the efficient trawl, and the experienced trawlers on board, to make a much more thorough examination of the bays than was formerly the case. From the fact, moreover, that the trawling operations are carried on under the same conditions as in commercial fishing, opportunities are afforded for certain observations of importance, as the proportion of the marketable and unmarketable fishes which are caught, the relation between the sizes of the fishes captured and the dimensions of the meshes of the net, and the amount of destruction of immature fish that occurs on different grounds and at different seasons.

For some years past, as mentioned in previous reports, by an arrangement with the Technical Education Committee of the County Council of Aberdeenshire, representative fishermen from various parts of the coast of that county have visited the Laboratory and Hatchery in spring to receive demonstrations on various aspects of the life-history and habits of fishes, such as may be of interest and use to them in the course of their calling. The fishermen have been much interested in the instruction they received, and as it appeared to the Board advantageous to encourage the desire for such knowledge on their part they issued a circular to the other sea-board County Councils inviting them also to send fishermen if they thought proper so to do, to attend a similar series of demonstrations. This invitation was accepted by the County Council of Argyshire, a number of fishermen from that shire subsequently visiting the Laboratory and Hatchery, and it is under consideration by some of the others.

TRAWLING INVESTIGATIONS.

In the course of the year the results of 91 hauls of the large otter-trawl in the closed waters were recorded, of which 75 were taken in the Moray Firth, 14 in Aberdeen Bay, and two in Sand-side Bay, on the north coast. The examination of the grounds was made in January, March, April, September, October, November, and December, the localities in the Moray Firth which were most thoroughly investigated being Burghead Bay and adjacent parts of the south coast, the Dornoch Firth, and the grounds off the coast of Caithness. Some hauls were also taken at Smith Bank and in the deeper portions of the Firth at the so-called "witch-grounds."

The aggregate number of fishes of all kinds caught in the recorded hauls was 63,525, and of these 44,538, or 70 per cent., were marketable, the other 18,987, or 30 per cent., being thrown

overboard as unmarketable, either because they belonged to species that are unsaleable, or, more commonly, because though edible they were too small to be taken to market.

The number of fishes captured in the various hauls and the proportion of the marketable and unmarketable are given in the tables appended to Dr. Fulton's report on the subject. The greater number of the marketable fishes consisted of plaice and haddocks, the former constituting 58 per cent. and the latter 25 per cent. of the total in this class; the proportion of none of the others reached three per cent. Among the unmarketable fishes, common dabs formed 32 per cent. and haddocks 30 per cent. The total number of turbot obtained was 54, and there were 394 brill, nine halibut, and five soles, and all these were marketable. 40 catfish and 22 hake were caught, all of which were marketable.

The investigations in the Dornoch Firth at the end of March were of interest from the discovery of a shoal of spawning cod on the edge of the rough and rocky ground. Several scores of cod were taken in each haul of the net, the largest number in a four hours' drag being 282. They were all spawning, eggs and milt flowing freely from them, and they were all of large size, the smallest females measuring from 33 to 35 inches and the smallest males from 29 to 30 inches. It was judged that the vessel was operating only on the fringe of the spawning shoal and that the greater bulk of the cod were on the rocky ground. Besides the cod, large numbers of spawning flounders were caught on this ground, where few of this species are obtained except in spring, and also spawning coalfish and plaice, in smaller numbers, and common dabs; very few haddocks were obtained and none of them were spawning.

It is probable that this area, lying about three miles from the shore in from 13 to 16 fathoms, is one of the important breeding-grounds for the food fishes in the Moray Firth.

The experiments made with a small-meshed net fastened around and outside the cod-end of the trawl confirmed the conclusions come to previously, that, contrary to the general opinion of fishermen, a very large proportion of the small fish, especially round fish, which enter the trawl as it is dragged along the bottom escape alive through the meshes, which appear to be distended by the resistance of the water.

THE HATCHING AND REARING OF FOOD-FISHES.

During last year the hatching of plaice was continued at the Marine Hatchery, Aberdeen, the number of eggs of that species collected from the spawning pond amounting in the season to an aggregate of about 39,600,000. The number of plaice-fry that hatched out and were retained in the hatching apparatus until approaching the post-larval stage was approximately 34,780,000, or 88 per cent., and they were liberated off Aberdeen Bay at various times in March, April, and May. The number was considerably below the total in 1903, when it was estimated that 65,940,000 eggs were collected, the fry obtained numbering 53,600,000. The

principal reason of the decrease was the difficulty in obtaining large adult plaice in the preceding autumn and winter to replenish the breeding stock in the pond, plaice of the class required being then exceedingly and unusually scarce on the grounds from which they are obtained.

The floating eggs were observed in the water of the spawning-pond about the middle of January, but they were then present in very small numbers, and the first collection was made on the 26th of that month, or three days later than in 1903. The last collection was on the 29th April, or more than a fortnight earlier than in the previous year. This is, no doubt, partly to be attributed to the smaller number of the spawners in the pond, as above mentioned, but it appears to have been also owing to the relatively greater intensity of spawning in the earlier part of the season in 1904, nearly 28 per cent. of the eggs being collected before the end of February, as compared with 18 per cent. in the same period in 1903. As usual, the greater number of the eggs were obtained in March, viz., 55·7 per cent., the percentage in that month in the preceding year being 56·2.

The duration of the period of development until hatching takes place varies with the temperature of the water at the time. At the beginning of the season, in January, when the temperature is low, the average time of incubation is about three weeks, while at the end of the season, when the temperature is several degrees higher, they hatch in about a fortnight. The larval fishes, after issuing from the eggs, are retained in the apparatus for several days until the yolk-sac is partly absorbed, and it is calculated that, taking the two periods together—the time of incubation and the period referred to subsequent to hatching—the eggs and larvæ are protected in the apparatus for about half of the time from the spawning of the egg until the young plaice is transformed and assumes the form and habit of the adult.

Since the establishment of the hatchery, the total number of plaice eggs dealt with amounts to 443,092,000, the fry liberated numbering 363,250,000. The number of fry of other fishes produced is as follows:—lemon soles, 5,727,000; turbot, 5,160,000; cod, 4,010,000; and other kinds, 2,000,000.

Owing to the circumstance that the hatchery is worked in conjunction with the Marine Laboratory, the expense of the hatching operations at the Bay of Nigg is not large compared with the number of fry produced, the annual expenditure in connection with it being estimated at about £100. As previously stated, the establishment was visited during the hatching season by representative fishermen from the shires of Aberdeen and Argyle, to whom the various processes adopted, as well as the fertilisation of the eggs and the development of the fish, were explained.

THE GROWTH AND AGE OF FISHES.

During the last few years a considerable amount of attention has been given to the study of the age of fishes and the rate at which they grow, and a number of papers dealing with the growth and age of the plaice, cod, haddock, whiting, and other forms have appeared in the recent reports of the Board. It is a subject that

has an important bearing on several problems connected with sea fisheries.

One method by which the growth and age of fishes is determined is by the tabulation of the measurements of large numbers taken at the same time and place. From the fact that the spawning season of a species, and, therefore, the rate at which a new generation makes its appearance, is usually limited to a few months of the year, the range of the sizes and the average size of the different generations or annual series differ from one another. By the tabulation of large numbers of measurements it is thus possible to distinguish different generations and to assign the range of size and the age of the fishes belonging to them. With the earlier generations this method is in most cases quite satisfactory, but owing to the very different rate at which members of the same generation grow, the larger of an earlier generation overtaking and exceeding in size the smaller members of the next older generation—a process which increases with age—it becomes difficult or impossible to separate the older generations from one another by this method.

Another method that has of late been largely adopted consists in determining the number of the zones or lines of growth in certain of the hard parts of the body. Fishes do not grow continuously throughout the year, their growth exhibiting a usually well-marked periodicity in relation to the changes of the temperature of the water, being as a rule, and in most places, rapid in summer and slow in winter. This periodicity is indicated by lines or zones on some of the skeletal structures, notably on the ear-bones, or otoliths, the scales, and certain bones of the skeleton, the structure which shows them best varying somewhat in different species. By counting the lines or zones it is thus possible to tell the age of a fish, just as by a similar method, and for a like reason, the age of a tree may be discovered by the number of rings present in a section of the trunk.

To the present report Mr. J. T. Cunningham contributes a paper on this subject, dealing specially with the plaice and the cod. He describes the structure and formation of the ear-bones and scales, and the mode in which the lines or zones are produced. One of the chief objects of the observations was to test the question how far the lines of growth in the skeletal structures of fishes were trustworthy indications of age—whether the annual increments of growth or deposit could be definitely distinguished and counted in all cases. He shows that it is often necessary to test the indications of one structure by an examination of the others, though in many instances the age of the fish may be well determined by the examination of one of them alone.

The result in regard to the two species mentioned is to show generally that they do not grow so fast or reach maturity so soon as is commonly supposed. It was found that cod at two years of age measure from ten to thirteen or fourteen inches in length, at three years from seventeen to nineteen, and at four years about twenty-seven inches, so that they would spawn as a rule in their fifth year. Plaice from two-and-a-half to about four inches were one year old, from about four to six-and-a-half inches they were two years old, while those at three years measured up to 12 inches.

At 13 and 14 inches they were mostly four years of age, while some in which the lines of growth indicated five years measured $11\frac{1}{2}$, $14\frac{3}{4}$, and $18\frac{3}{4}$ inches, and one measuring 20 inches was shown to be four years old.

The paper is illustrated by three plates showing the otoliths, scales, and bones.

THE LIFE-HISTORY OF THE LOBSTER.

In the present report will be found a paper, illustrated by four plates, in which Dr. H. C. Williamson gives the results of his observations on the life-history of the lobster. An account is furnished of the experiments on lobster-culture which were made at the hatchery, the "berried" or egg-bearing females being kept in a suitable tank, the larvæ as they hatched being carried away in the overflow to receptacles where they were retained. Hatching was found to take place during the night, and the first young lobsters were observed on 11th July.

The larval and early young stages which were reared at the Laboratory are described and figured in detail. Certain dimorphic forms of the zoëa were discovered among the larvæ, and they attracted attention, since, so far as known, such forms have not hitherto been recorded and described. Attention was directed to the behaviour of the lobsters during the time they were kept in confinement at the Laboratory, that is to say, three years in certain cases. Among them only one was known to have spawned its eggs. Casting occurred frequently, more frequently apparently than normally occurs with lobsters in the sea, and the increase in size immediately after moulting was found to be very small; reproduction, moreover, seemed to be inhibited.

Various observations made on the condition of the ovary, the periods of spawning and hatching, the number of eggs carried by the female, the growth of the lobster, and on other points connected with its life-history and habits, are incorporated in the paper.

Dr. Williamson also furnishes a further note on the life-history of the edible crab, treating specially of the hatching of the young.

THE PARASITES OF FISHES.

Dr. Thomas Scott, who is still prosecuting his researches on the parasites of fishes, contributes a paper on these organisms to the present report, in which several species not previously recorded from the Scottish seas are described, the descriptions being illustrated by a number of figures. This paper contains descriptions of seventeen species, twelve of which belong to the Crustacea and five to the Trematoda.

One of the crustacean species described is found living in the nasal fossæ of several kinds of fishes, as the cod, haddock, whiting, &c. Another was obtained in the mouth of a three-bearded rockling, and others on a sturgeon, a porbeagle shark, and other fishes.

The Trematoda, which are leach-like in form, were obtained on the gills of the grey gurnard, the ballan wrasse, and the bass (*Labrax lupus*).

THE MARINE CRUSTACEA.

A paper, illustrated by four plates, is also contributed to the present report by Dr. Thomas Scott on a number of marine crustacea, obtained in collections made during various fishery investigations, especially the trawling investigations in the Moray Firth.

All the forms described are small; they are for the most part free-swimming in their habits and belong to the Copepoda, a group that constitutes a large proportion of the food of the edible fishes in their young stages. Of these free-swimming crustaceans four are new to science and are now described for the first time. A few species that live as parasites on other crustaceans are also recorded. They belong to the somewhat abnormal Choniostomatidæ; two of these are also new to science and are now described for the first time in this report.

THE TAY SPRAT FISHERY.

A paper is included in the present report in which Mr. John Fletcher gives an account of the bag-net fishing for sprats on the Tay in the season 1904-1905. The methods and course of the fishing and the situation of the ground where the sprats are taken are described, but the chief part of the paper deals with the composition of the catches. In forty-six samples examined at various periods from October to February inclusive, comprising 43,871 fishes, the number of young herrings was found to be 26,037, the sprats numbering 16,992; there were also 581 specimens of other food fishes, mostly whiting and cod, as well as 261 specimens of unmarketable and inedible forms. The herrings measured from $1\frac{1}{2}$ inches to 7 inches in length.

The quantity examined represented about one-thousandth part of the entire season's catch. On the basis mentioned tables are given showing the estimated composition of the catches throughout the season, from which it appears that in the 1348 crans taken the number of young herrings was approximately nearly $23\frac{1}{2}$ millions, while the sprats numbered a little over 21 millions. The percentage proportion of herrings increased gradually and steadily from the commencement of the season in October, when it was 20·4, to January, when it was 78·2.

THE YOUNG OF THE CONGER.

In last year's report two specimens of the young of the conger (*Leptocephalus*) at different stages were described, the earlier being known as *Leptocephalus Morrisii* and the older as *L. punctatus*, and both were taken in the Moray Firth. Last May another specimen of *L. punctatus* was captured in Aberdeen Bay in from four to five fathoms of water and brought alive to the Laboratory, as well as the head part of a third specimen. They are described by Dr. Fulton in the present report. *Leptocephali* are exceedingly rare, and the capture of four in so short a time is of interest.

THE SPAWNING OF THE COD IN AUTUMN IN THE NORTH SEA.

Dr. Fulton also describes further observations in connection with the discovery that shoals of cod spawn in August, September, and

October on certain grounds lying off the coast of Norway, and about 190 miles N. by E. of Aberdeen. The previous description appeared in the bulletin (*Publications de Circonstance*) of the International Council for the Exploration of the Sea. The fact that the cod, whose great spawning-time, as is well known, is in spring, should also spawn in autumn is of interest. It has been shown, moreover, that the temperature of the water at the grounds referred to when spawning occurs is the lowest for the year.

INVESTIGATION ON THE HERRING IN THE FIRTH OF CLYDE

In connection with the winter herring fishing at Ballantrae Bank, off the coast of Ayr, arrangements were made for an investigation of the conditions of the fishing in relation to the operation of the Bye-law, No. 18, by which the use of the seine for the capture of herrings within a defined area there is prohibited. No fishing however took place last year. Only one trial was made by a single boat, and the catch was only about seven hundred small herrings. The "appearances" of herrings were not favourable, and the market prices, as given in the newspapers, were so low that the men did not think it worth while to start the fishing and give up the cod-net and line fishing. That there were herrings on the Bank was shown by their presence in the stomachs of cod and saithe, as reported by the Fishery Officer, and by the coating of herring spawn on the cod nets.

An investigation is also being made on the herrings in other parts of the Firth of Clyde, more especially in Lochfyne, where monthly observations are made on the temperatures, the abundance of herring-food, &c., and marking experiments have been instituted to determine, if possible, the migratory movements of the herrings.

GENERAL INDEX TO THE SCIENTIFIC REPORTS.

A paper, prepared by Dr. Fulton, is given in the present report, embodying a general index to the scientific reports of the Board since the commencement of scientific investigations in 1882. The reports are twenty-two in number, and as they embrace a great variety of subjects connected with the sea fisheries in their scientific aspects, it is hoped the index may be useful to those engaged or interested in fishery investigations.

We have the honour to be,

Your Lordship's most obedient Servants,

ANGUS SUTHERLAND, *Chairman*.

D. CRAWFORD, *Deputy-Chairman*.

D'ARCY W. THOMPSON.

W. R. DUGUID.

L. MILLOY.

D. MEARNS.

H. WATSON.

WM. C. ROBERTSON, *Secretary*.

SCIENTIFIC REPORTS.

I.—TRAWLING INVESTIGATIONS. By Dr. T. WEMYSS FULTON, F.R.S.E., Superintendent of Scientific Investigations.

INTRODUCTORY.

The investigations into the condition of the fishing grounds in certain parts of the closed waters, particularly in the Moray Firth and Aberdeen Bay, which were begun a few years ago by the employment of commercial steam trawlers, were continued last year as frequently as circumstances allowed. Trawlings were made in January, March, April, September, October, November, and December, the total number of recorded hauls in the closed waters amounting to 91, of which 14 were made in Aberdeen Bay, 75 in the Moray Firth, and 2 in Sandside Bay, on the north coast of Scotland. The localities in the Moray Firth which were most thoroughly examined were Burghead Bay and adjoining parts of the south coast, the Dornoch Firth, and the grounds off the coast of Caithness. A few hauls were also taken on Smith Bank, and in the deeper parts of the Firth, at the so-called "witch-grounds."

The aggregate number of fishes taken in the course of these trawlings, so far as they were completely recorded, was 63,525, and of these 44,538 were taken to market, the remaining 18,987 being thrown overboard, either because they belonged to species which are not edible, or, more commonly, because they were too small to be marketable. The proportions of the marketable and unmarketable in each of the recorded hauls are given in the Tables appended.

Records were also made of a number of hauls of a steam trawler which fished at the Farøes in the month of May, and these are likewise included in the Tables.

One of the chief objects of these trawling investigations is to ascertain as far as possible the changes which may occur in the abundance of the food and other fishes in the closed waters in different years and at different seasons, but observations are also made on the reproduction of the fish, their spawning, food, &c., and on various other matters connected with their life-history, while at the same time records are made of the surface and bottom temperatures of the water on the various grounds visited. The employment of commercial vessels for this purpose is associated with certain disadvantages; but from the fact that the actual trawling work is carried on precisely as it is when fishing for market purposes, opportunities are afforded for a number of observations bearing on this method of fishing, as, for example, the proportion of the marketable and unmarketable fishes which are captured, the relation between the size of the fishes taken and the size of the meshes of the net, the vitality of the fishes, &c. Collections are also made of the floating organisms, or plankton, and of fish eggs and larvæ, and experiments conducted with small-meshed nets with the view of procuring collections of fishes of various sizes in connection with the study of their rate of growth, distribution, &c.

With the large commercial trawl, the efficient ship, and the experienced trawlers in charge, it is possible to make a much more thorough and extensive examination of the grounds than was previously possible.

The work has been sometimes carried on under difficulty, inasmuch as since the reduction of the Vote for Scientific Investigations, when the International researches were initiated, no assistance was available, and it was impossible for me alone to conduct these experiments with the regularity that was desirable. In autumn of last year, Dr. H. C. Williamson was re-appointed to the scientific staff of the Board, and I have to thank that gentleman for his assistance in these investigations.

I.

The first of the series of investigations in Aberdeen Bay and the Moray Firth was made in January, from the 14th to the 23rd, the steam trawler "Ern" being employed, one of the objects being to obtain a supply of large living plaice for the hatchery at the Bay of Nigg. Besides Aberdeen Bay, the places visited were the grounds off the Ord of Caithness and Lybster, Dunnet Bay, and Sandside Bay, these two being situated on the north coast. Three hauls were made in Aberdeen Bay on the 14th, a strong wind blowing from the south-west with rain. The first was in from 5 to 20 fathoms, off Newburgh, for four hours and five minutes, and the catch was small, comprising 387 fishes, of which 360 were marketable and 27 unmarketable. Haddocks and codling formed the bulk of the catch, there being few plaice, and they were all small. The other two hauls were also taken off Newburgh, in from 4½ to 9 fathoms, and they were still less productive, the respective totals being 218 and 293 fishes, the hauls lasting for four hours and four hours and five minutes. Plaice were again very scarce, and haddocks were not numerous, but a considerable number of codling were taken. Among the fishes in the second haul were 14 herrings and 22 sprats. In the three hauls, lasting for twelve hours and ten minutes, 898 fishes were taken, of which 783 were marketable and 115 unmarketable. The numbers of marketable and unmarketable of the various species were as follows :—

	Cod.	Codling.	Haddock.	Whiting.	Plaice.
I.	5	186	431	.	71
II.	.	12	19	27	.
Total	5	198	512	27	71
	Com. Dab.	Long Rough Dab.	Sprat.	Herring.	Starry Ray.
I.	28	.	.	.	.
II.	1	4	22	14	16
Total	29	4	22	14	16

While all the plaice were marketable, there were none of medium size, and none large; all were small. The majority of the haddocks, on the other hand, were large or medium, viz., 330 large, 109 mediums, and 54 small or thirds.

In the Moray Firth the first haul was made on the 17th, off Lybster, in about 25 fathoms, a strong breeze blowing from the south-west. The number of fishes obtained in the four hours' drag was 352, of which 206 were marketable and 146 unmarketable. The catch comprised 20 cod, 146 haddocks, and 128 plaice; all the haddocks except 46 small were unmarketable, and most of the plaice were also small. The next haul was made in rather deeper water, 34 to 36 fathoms, a little farther off, and a rather better catch was got, viz., 522 fishes, of which 330 were marketable. Haddocks and plaice were again most numerous—315 and 162 respectively—and they were, as a rule, larger, especially the plaice, 112 being either large or medium. Other seven drags were taken off Lybster in from 23 to 35 fathoms, with as a rule, poor results, though the weather had improved and the sea was smooth. Omitting one of these, in which the net was split and only 108 fishes secured, the total number of fishes caught in the thirty-three hours and ten minutes fishing was 3478, of which 2005 were marketable and 1473 unmarketable. The largest total number taken in any one haul was 522; the largest number marketable in any haul was 330, and the lowest 118. Haddocks and plaice formed the bulk of the fish caught, the former numbered 1898, of which rather more than half were marketable; the latter numbered 875, all of which were marketable. The total of the marketable haddocks and plaice according to size was as follows:—

	1st	2nd	3rd	4th	Total
Haddock	63	80	46	780	969
Plaice	118	387	342	28	875

The accompanying Table gives the particulars of the marketable and unmarketable fishes of the eight hauls:—

	Cod.	Codling.	Haddock.	Whiting.	Coal-fish.	Cat-fish.	Brill.	Plaice.
I.	29	67	969	.	2	2	2	875
II.	-	58	929	204	-	.	-	-
Total	29	125	1,898	204	2	2	2	875
	Lemon Dab.	Witch.	Common Dab.	Long Rough Dab.	Herring.	Starry Ray.	Skate.	Angler.
I.	39	2	-	-	.	3	12	3
II.	.	.	254	7	1	.	11	9
Total	39	2	254	7	1	3	23	12

On the 18th, owing to the comparatively poor catches on the grounds off Lybster, the vessel left for the north coast to try Sandside Bay, but the wind in the Pentland Firth was so strong that it was forced to return. On the following night Sandside Bay was reached and three

hauls were made there. The first was imperfect, being a "foul" shot, owing to a turn in the net, and only 127 marketable fishes were secured, mostly plaice and haddocks; the depth was from about 40 to 43 fathoms. In the next haul on the same ground, in 40 to 43 fathoms, lasting four hours and five minutes, 324 fishes were taken—169 being marketable and 155 unmarketable. Most consisted of haddocks and plaice; there were also 14 gurnards and 31 dog-fishes. A third haul for four hours and ten minutes, in from 28 to 40 fathoms, was still less productive, the total being 250 fishes, 175 being marketable and 75 unmarketable. The numbers of haddocks and plaice of the various classes according to size, in the two hauls were these:—

	1st	2nd	3rd	4th	Total
Haddock	5	56	10	62	133
Plaice	20	46	46	—	112

The following Table gives the marketable and unmarketable fishes caught in the two hauls, the time of fishing being 8 hours and 15 minutes:

	Cod.	Codling.	Haddock.	Whiting.	Gurnard.
I.	2	4	133	-	-
II.	-	9	112	32	30
Total	2	13	245	32	30
	Plaice.	Lemon Dab.	Common Dab.	Skate.	Dog-fish.
I.	112	58	35	-	-
II.	-	-	-	16	31
Total	112	58	35	16	31

Dunnet Bay was then tried, and a haul taken in 30 to 36 fathoms. After towing for an hour and three-quarters the net caught, and on being brought up it was found that the ground rope was broken, and a good deal of the net missing; what was left contained five marketable fishes.

The vessel accordingly returned to the Moray Firth and started fishing south of Lybster, on the grounds off the Ord of Caithness. The wind was still from the south-west and very squally. The first haul, for 4½ hours, was made in 23 and 24 fathoms, and 405 fishes were secured, of which 170 were marketable and 235 unmarketable. Among the former were 19 cod, 107 haddocks, and 78 plaice, as well as some lemon dabs and common dabs. The second haul for the same time on the same ground, in 23 to 25 fathoms, was slightly better, 446 fishes being taken—169 marketable and 277 unmarketable. Haddocks, plaice, and dabs were the chief fish represented. Other six hauls were taken on this ground, the catches being under those described, and in one of the hauls the trawl net was practically destroyed, nothing coming up but the ground rope. In the seven hauls, the duration of which was 29 hours and 35 minutes,

the aggregate number of fishes caught was only 2086—895 being marketable and 1191 unmarketable—which was extremely poor fishing. The numbers of haddocks and plaice of the various sizes taken in the hauls were as follows :—

	1st	2nd	3rd	4th	Total
Haddock	57	164	65	—	286
Plaice	91	186	192	18	487

The particulars as to the marketable and unmarketable in the seven drags are these :—

	Cod.	Codling.	Haddock.	Whiting.	Coal-fish.	Cat-fish.	Conger-Eel.
I.	36	38	286	.	4	3	2
II.	.	29	478	72	.	.	.
Total	36	67	764	72	4	3	2

	Plaice.	Lemon Dab.	Common Dab.	Long Rough Dab.	Skate.	Angler.
I.	487	33	.	.	16	.
II.	.	.	439	129	11	33
Total	487	33	439	129	27	33

The vessel then steamed to the so-called “witch-grounds,” off Kinnaird Head, and made two drags there on the 23rd. Owing to want of time the unmarketable fishes in these drags, which were very numerous, were not recorded. In the first, for four hours and fifteen minutes, in from 40 to 45 fathoms, 168 marketable fishes were obtained, chiefly haddocks and witches; the offal, or unmarketable fishes, filled seven baskets, the contents of one of which were counted, viz., 306 dabs, 183 long rough dabs, 94 haddocks, and 42 whittings. In the second drag, in from 40 to 50 fathoms, 163 marketable fishes were secured, comprising 4 cod, 7 codlings, 62 witches, and 90 haddocks; the offal or unmarketable fishes filled three baskets, and were not enumerated. Small haddocks, too small to be marketable, were numerous in this locality; the numbers of the various classes of marketable haddocks were, 1st 35, 2nd 65, 3rd 68.

Another haul for an hour and ten minutes was made here in about 50 fathoms with the small-meshed net laced around the cod-end, in order to catch the small fishes, as described in previous reports; 2812 fishes were taken, belonging to 18 species, as follow :—

Cod, - - - -	7	Witch, - - - -	39
Haddock, - - -	249	Lemon Dab. - - -	3
Whiting, - - -	122	Common Dab, - -	986
Poorcod, - - -	7	Long Rough Dab,	1048
Norway Pout, - -	250	Herring, - - - -	2
Three-Bearded Rockling,	2	Sprat, - - - -	3
Four-Bearded Rockling,	5	<i>Lumpenus</i> , - - -	65
Grey Gurnard, - -	2	Spotted Dragonet	15
Plaice, - - - -	4	Hagfish, - - - -	3

The quantity of fish landed at the end of the voyage, according to the market returns, amounted to 99 cwt., as follows :—

Cod.	Codling.	Ling.	Saithe.	Hake.	Haddock.	Whiting.	Turbot.	Halibut.	Brill.
23	4	1	2½	½	16½	½	½	½	½
Lemon Dab.		Plaice.	Witch.	Megrim.	Conger.	Skate.	Cat-fish.		
3½		27	6½	½	½	3	½		

II.

The second series of trawlings was made at the end of March and the beginning of April, the steam trawler “Star of the Wave” being employed. The first place visited was Burghead Bay, where several hauls were taken, in from 4 to 16 fathoms, on 28th and 29th. In the first, which was carried into water of 30 fathoms depth, 1202 fishes were taken—780 being marketable and 422 unmarketable. The fishes most abundantly represented were common dabs, plaice, haddocks, and witches ; there were also 24 brill and 19 lemon dabs, all marketable, as well as 5 herrings. All the haddocks and most of the plaice were small. The next three hauls were made nearer the shore, in water of from about 4 to 16 fathoms. In the first of these 975 were secured—574 being marketable and 401 unmarketable. Common dabs and plaice were best represented, numbering respectively 360 and 325—90 of the dabs and 302 of the plaice being marketable. The catch also included 89 haddocks—all small, and 37 marketable—6 catfish, 20 lemon dabs, and 35 witches. The second haul brought up 698 fishes, mostly plaice and dabs, the marketable fishes including 23 brill, 2 turbot, 10 lemon dabs, and 9 witches, as well as 18 haddocks, 3 cod, and 2 catfishes. The third haul, for five hours and twenty-six minutes, yielded 2331 fishes, of which 1181 were marketable and 1150 unmarketable. The catch included 1116 common dabs, 576 plaice, 208 haddocks, 30 lemon dabs, 13 brill, and 2 turbot ; there were also in this haul 28 anglers, 8 herring, and a lumpsucker.

The aggregate number of fishes in the three inshore drags referred to was 4004, 2168 being marketable and 1836 unmarketable. The numbers of haddocks and plaice of the various classes according to size were as follows :—

	1st	2nd	3rd	4th	Total
Haddock	16	—	204	—	220
Plaice	96	276	416	335	1123

The details of the four hauls referred to are summed up in the accompanying Table :—

	Cod.	Codling.	Had-dock.	Whiting.	Coal-fish.	Cat-fish.	Gur-nard.	Tur-bot.	Brill.	Floun-der.
I.	8	19	440	220	2	17	11	4	100	-
II.	.	27	99	53	.	.	8	.	-	9
Total	8	46	539	273	2	17	19	4	100	9

[Continued.]

	Plaice.	Lemon Dab.	Witch.	Com. Dab.	Long Rough Dab.	Thorn-back.	Herring.	Angler.	Lump-sucker.
I.	1,345	79	141	483	.	69	.	30	.
II.	95	2	60	1,630	198	16	13	25	3
Total	1,440	81	201	2,113	198	85	13	55	3

Some other hauls were made in this district, but in somewhat deeper water. In the first of these off Burghead, in 44 to 45 fathoms, and lasting four hours and twenty minutes, 1638 fishes were captured, 1280 being marketable and 358 unmarketable. The number of haddocks increased to 817, most of them being small; plaice diminished to twenty, mostly large and medium; there were also 269 witches, 106 lemon dabs, a megrim, a brill, and 8 cod. In the next haul, lasting three hours and thirty-five minutes, in the same depth, 4030 fishes were obtained, 2483 being marketable and 1547 unmarketable; nineteen species were represented. Haddocks were most abundant, numbering 1927; there were 1358 dabs, 282 witches, 251 whiting, 27 lemon dabs, and 10 plaice. Ten Norway pouts, a herring, a bib, and 2 Lumpenus were also taken, as well as 5 marketable hake. The next haul was begun in the same place, the vessel towing towards Lossiemouth, where the net was hauled in 16 fathoms. The drag lasted for two hours and twenty-five minutes, and 1427 fishes were taken, comprising 837 haddocks, 139 whittings, 40 plaice, 51 lemon dabs, 6 witches, as well as 4 cod, 2 ling, and a Norway pout.

In these three hauls in deeper water the total number of fishes caught was 7095, 4846 being marketable and 2249 unmarketable, the time of fishing being ten hours and twenty minutes. The sizes of the haddock and plaice taken were as follows:—

	1st	2nd	3rd	4th	Total
Haddock	235	154	3113	—	3502
Plaice	17	44	14	—	75

The particulars are given in the following Table:—

	Cod.	Cod-ling.	Hake.	Ling.	Had-dock.	Whit-ing.	Gur-nard.	Brill.	Plaice.	Lemon Dab.	Witch.
I.	19	10	22	2	3,502	530	17	5	75	176	429
II.	.	5	.	.	79	12	8	.	.	8	128
Total	19	15	22	2	3,581	542	25	5	75	184	557

	Megrim.	Com. Dab.	Long Rough Dab.	Thorn-back.	Grey Skate.	Angler.	Nor-way Pout.	Her-ring.	Bib.	Lum-penus.
I.	2	47	.	.	.	10	.	.	.	.
II.	.	257	1,720	10	2	5	11	1	1	2
Total	2	304	1,720	10	2	15	11	1	1	2

A haul for four hours was made in thirteen fathoms off Lossiemouth, the vessel trawling around a dan, but the catch was very poor, the number of marketable fishes secured being 191, and the unmarketable 79, a total of 270. There were 107 plaice, 36 haddocks, eight brill, a cod, a catfish, and a lumpsucker in the catch.

The next place visited was the Dornoch Firth. On 30th March the trawl was dropped in sixteen fathoms, with Dunrobin Castle bearing N.W. and Tarbert Lighthouse about S. $\frac{1}{2}$ E.; a sweep was made around the bay into four fathoms and out again, the haul lasting for four hours. The weather was fine and the sea smooth.

In the hauls made here a special cod-end with large meshes was used, and the catches, especially of the unmarketable fishes, were therefore smaller than would have been the case otherwise; the records cannot thus in this respect be compared with the foregoing.

The catch consisted of 400 fishes, of which 354 were marketable. The plaice numbered 138, and there were 69 cod and 123 flounders. In the next haul, in the same locality, 210 fishes were taken, the catch comprising 43 cod, 87 plaice, 38 flounders and 29 skates and rays. Other four drags were made here, and the aggregate catch for the six hauls, comprising twenty-four hours and five minutes fishing, was 1932 fish, 1837 being marketable.

The details of the catches are given in the adjoining Table; what is stated above as to the mesh of the cod-end must be borne in mind.

	Cod.	Codling.	Coal-fish.	Haddock.	Cat-fish.	Brill.	Plaice.	Lemon Dab.
I.	754	5	9	35	12	4	581	33
II.	.	1	.	.	.	.	6	.
Total	754	6	9	35	12	4	587	33

	Witch.	Flounder.	Common Dab.	Long Rough Dab.	Thorn-back.	Sprat.	Grey Skate.
I.	15	235	57	.	92	.	5
II.	.	32	17	3	11	2	23
Total	15	267	74	3	103	2	28

Large and medium-sized haddocks were present in the catches, the numbers taken being—large 86, medium 80, small 130, fourths, 152; many of the smaller haddocks would escape through the mesh of the cod-end used.

The fishing in the Dornoch Firth on this occasion was of special interest, for several reasons. Cod were taken in quite unusual numbers, a shoal of spawning fish having been hit upon, and each haul of the net was characterised by the large number of cod present. On hauling the net, the cod-end, in which the fish were contained, could be seen floating at the surface some distance away from the vessel; this is always the case with large catches of the greater round fishes. The greatest number of cod caught in one haul of four hours was 282, but in each drag the net contained many scores. Owing to the weight of fish

the cod-end was not brought in to the deck at first in the ordinary way, but a hole was cut in it as it lay alongside the vessel and the cod removed by a "clip" and passed along to the fish-hold; then the net was brought aboard. As mentioned, the cod were all spawning, eggs and milt flowing freely from them, and I was struck with their large size. There were no small cod among them. It was not possible to measure them all, but the smallest and the larger were put aside and measured. The smaller female fishes ranged from 33 to 35 inches; two males measured $29\frac{1}{2}$ and 30 inches; among a few "codling" taken I found one measuring $27\frac{1}{2}$ inches, quite immature. Several smaller-sized cod were brought up in a state of decay, and had been lying on the ground dead for some time; whether these had been caught previously by some other trawler, escaped from the net and perished, was unknown. The skipper (S. Caie) stated that at Farøe they sometimes get as many as sixty score of cod (1200) in a single drag of three hours' duration.

Besides the cod, several of the other fishes taken at this place were ripe and spawning. Among the few coalfish caught I found a female, measuring $40\frac{1}{2}$ inches, half spent, with the eggs flowing freely, and several of the males were also mature. Most of the flounders, of which 267 were taken—235 of them marketable—were also spawning, and it is evident from a comparison of the records at other times of the year that shoals of flounders come out from the shallower waters—no doubt largely from the stretch of brackish water west of Gizzing Briggs—at this season in order to spawn. Spawning females were found from ten inches upwards, and spawning males from a size of eight inches. Some plaice were also found ripe and spawning, though the number of this fish taken was relatively small, and still more were spent. Among the common dabs the condition was not so far advanced, most of the larger ones having the reproductive organ large and ripe, and a few were just commencing to spawn.

On this ground, therefore, spawning cod, coalfish, flounders, plaice, and common dabs were found on the 30th and 31st March. It lies about three miles from the nearest land, on the edge of, and partly over, the rough ground that under ordinary circumstances is avoided by trawlers, the depths being from thirteen to fifteen or sixteen fathoms. It is possible, I may say, to fish over the rough ground when cod or other round fishes are present in large numbers, the trawlers explaining that the cod-end, and perhaps most of the net, is buoyed up from the bottom by the fish. The locality lies well within the Dornoch Firth, and I think it will be found that there is some peculiarity about the currents here that tends to distribute the floating eggs, the movement of the water being northwards, rather as an eddy.* From the small number of plaice got it is not certain that they spawn on these grounds in any great numbers, and the same remark may be made about the coalfish. Clearly, however, cod and flounders spawn there in great numbers.

Before leaving the Dornoch Firth a haul was made for half an hour with the small-meshed net around the cod-end, the trawl going into four fathoms. The number of fishes taken was 1107, belonging to ten species, as follows:—

Codling, -	-	1	Plaice, -	-	74
Haddock, -	-	2	Flounder, -	-	53
Whiting, -	-	27	Common Dab, -	-	46
Herring, -	-	16	Sprat, -	-	870
Little Sole, -	-	2	Common Pipefish,		16

* *Vide* Fulton, "The Currents of the North Sea and their Relation to Fisheries," *Fifteenth Annual Report, Part III.*, p. 343.

The vessel then steamed to the south coast of the Moray Firth and took a haul with the small-meshed net around the cod-end, between Findhorn and Burghead, in 30 to 32 fathoms, the haul lasting for an hour. The total number of fishes obtained was 1753, belonging to eighteen species, as follows :—

Codling, - -	10	Plaice, - -	1
Coalfish, - -	1	Lemon Dab, -	14
Haddock, - -	19	Common Dab, -	68
Whiting, - -	20	Witch, - -	221
Norway Pout, -	387	Long Rough Dab,	516
Herring, - -	36	Megrim, - -	1
Sprat, - -	74	Flounder, - -	4
<i>Lumpenus</i> , - -	365	Thornback, - -	1
Dragonet, - -	2	Angler, - -	13

Smith Bank was then visited, and a haul made there with the small-meshed net for twenty-five minutes (the net catching on the bottom after that interval and being hauled) in 22 fathoms. The number of fishes caught was 1545, belonging to thirteen species, as follows :—

Codling, - -	34	Plaice, - -	2
Haddock, - -	444	Lemon Dab, -	10
Whiting, - -	502	Common Dab, -	99
Ling, - -	1	Long Rough Dab,	6
Poorcod, - -	436	Catfish, - -	3
Norway Pout, -	6	Herring, - -	1
Gurnard, - -	1		—

Before returning to Aberdeen a haul with the small-meshed net was taken in Aberdeen Bay, in the northern part, but the net came up much torn and no fishes were caught ; there was a heavy sea and a strong wind.

According to the market statistics, the quantity of fish landed amounted to 246 $\frac{3}{8}$ cwts., as follows :—

Cod.	Codling.	Saithe.	Haddock.	Whiting.	Turbot.	Brill.	Lemon Dab.	Plaice.
178 $\frac{1}{2}$	$\frac{1}{2}$	1 $\frac{1}{2}$	17	2 $\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	2 $\frac{1}{2}$	21 $\frac{1}{2}$
			Dabs.	Witch.	Skate.	Cat-fish.	Monk.	
			2 $\frac{1}{2}$	5 $\frac{1}{2}$	9	8 $\frac{1}{2}$	1	

III.

The next series of trawlings was made at the end of September and the beginning of October, the steam trawler "Star of the Ocean" being employed. The first place visited was the deep hole off Fraserburgh, where a haul was made in 75 fathoms, a dan being put down in 70 fathoms. In sounding, a depth of 130 fathoms was got in the locality, fine dirty sand being on the armature of the lead. The net became fast and it was hauled in two hours in 35 fathoms. The catch comprised 1177 fishes, of which 900 were marketable and 277 un-marketable. Haddocks were best represented, the number taken being 825, but most of them were small. There were also 44 cod and 170 codling, 44 whiting, 11 gurnards, 18 lemon dabs, 11 megrims, and 1 witch, with some other fishes. No plaice or common dabs were caught.

Burghead Bay was then visited and a couple of drags made in from 5 to 12 fathoms. In the first, which lasted for four hours and ten

minutes, 597 fish were caught, 184 being marketable and 413 unmarketable. The catch was made up mainly of small haddocks and plaice, together with common dabs. In the second haul, for four hours and ten minutes, 1339 fishes were secured, of which 556 were marketable and 783 unmarketable. The catch was again chiefly composed of small haddocks. In these two hauls, the time of fishing being eight hours and twenty minutes, 1936 fishes were taken, of which 740 were marketable and 1196 unmarketable. The haddocks numbered 1565, no less than 999 of them being too small to be marketable. The numbers of haddocks of the various classes were these :—

	1st	2nd	3rd	4th	Unmarketable	Total
Haddock	27	48	491	—	999	1565

The plaice were also, as a rule, small, but the separate sizes were not noted.

The details regarding the different species are as follows:—

	Cod-ling.	Had-dock.	Whit-ing.	Gur-nard.	Plaice.	Lemon Dab.	Common Dab.	Long Rough Dab.	Thorn-back.	Ang-ler.
I.	4	566	27	.	135	5	127	.	3	.
II.	.	999	16	37	8	.	.	6	.	2
Total	4	1,565	43	37	143	5	127	6	3	2

A number of hauls were then taken between Burghead Bay and Lossiemouth, in water from 7 to 12 fathoms deep. In the first, which lasted for three hours and fifteen minutes, 498 fishes were caught, 287 being marketable and 211 unmarketable. The catch comprised 347 haddocks—nearly half of them too small to be taken to market—and 42 cod. In the second, for four hours and thirty-five minutes, 892 fishes were caught, 458 being marketable and 434 unmarketable. Haddocks again formed the bulk of the catch, numbering 587, of which less than half were marketable, and there were also 145 plaice and seven cod. Most of the other hauls made in this place were less productive, but in one the number was considerably exceeded. It was for four hours and five minutes, and 3157 fishes were captured, of which 972 were marketable and 2185 unmarketable. The catch comprised 1425 haddocks, 879 being too small to go to market; 358 plaice, all but 6 marketable; 1082 common dabs, 201 gurnards (none taken to market), 51 codling, 4 cod, 2 turbot, 8 brill, and 5 lythe or pollack.

In the seven hauls between Burghead and Lossiemouth, the duration of fishing being twenty-eight and a half hours, the total number of fishes caught was 6637, or an average of 2328·9 per ten hours' fishing; the marketable fishes numbered 2880, or an average of 1010·4 per ten hours, the unmarketable numbering 3757, or an average per ten hours of 1318·3. Of 2871 haddocks caught rather more than half, viz., 1474, were unmarketable, while of 1203 plaice only 7 were too small to be taken to market. In one of the hauls 5 lythe were caught, in another 4 coalfish, too small to be marketable; and in another 4 fine black soles, a fish which is very rarely caught in these waters. Of the 1397 haddocks, 96 were large, 204 mediums, and 1097 small or thirds; a classification into thirds and fourths was not adopted on this occasion.

The accompanying Table gives the particulars of the catches of the seven hauls combined.

	Cod.	Codling.	Haddock.	Whiting.	Coalfish.	Lythe.	Gurnard.	Turbot.	Brill.
I.	61	90	1,397	33	-	5	.	4	17
II.	.	.21	1,474	46	4	.	589	.	.
Total	61	111	2,871	79	4	5	589	4	17

	Plaice.	Lemon Dab.	Black Sole.	Witch.	Common Dab.	Angler.	Thornback.	Wrasse.
I.	1,196	37	4	2	26	-	7	1
II.	7	.	.	.	1,527	86	3	.
Total	1,203	37	4	2	1,553	86	10	1

A haul was also made on the usual ground off Lossiemouth, in 17 fathoms, for one hour and forty-five minutes. The catch consisted of 605 fishes, 405 being marketable and 200 unmarketable, all the latter consisting of gurnards. There were 314 haddocks and 80 plaice ; about half of the haddocks were large and mediums, and half small, while all the plaice were large and mediums. In the hauls in Burghead Bay, and between it and Lossiemouth, several hundred squids and a few edible crabs were taken.

The vessel then steamed to the Dornoch Firth, where a drag with the small-meshed net around the cod-end was made for an hour and five minutes in from 10 to 12 fathoms. The catch of both nets numbered 1035 fishes, of which 697 were marketable, mostly of small haddocks ("thirds"). The numbers of the various species were as follows :—

Codling, -	-	-	3	Plaice, -	-	-	12
Haddock, -	-	-	833	Common Dab, -	-	-	32
Whiting, -	-	-	133	Gurnard, -	-	-	22

Another drag was made here, but the net had a twist on it, and only 133 fishes were caught in the four hours that the haul lasted, 56 being marketable.

The grounds off Lybster were then visited on 3rd October, and a drag taken for four hours and ten minutes in from 26 to 34 fathoms. The catch comprised 991 fishes, 400 being marketable and 591 unmarketable. Haddocks formed the bulk of the catch, numbering 811, of which only 340 were marketable ; there were also 60 gurnards, 23 codlings, and 58 lemon dabs, as well as smaller numbers of other species. Two dog-fishes were taken in the net, and also a number of squids.

The next place visited was Smith Bank, where a haul about the middle, in 19 and 20 fathoms, was taken for an hour and ten minutes. The cod-end contained an immense quantity of gurnards, which filled fifteen baskets. One which was counted contained 178 of various sizes, so that on this basis the total number would be about 2670. There

were also in the cod-end 79 haddocks, nearly all small, 13 plaice, and 76 common dabs. The contents of the small-meshed net filled six baskets, one of which contained 348 small haddocks, 93 dabs, 4 whittings, 3 codlings, 103 gurnards, and 4 lemon dabs, so that the total number of small fishes which had passed through the meshes of the cod-end would number about 3300, mostly haddocks and gurnards.

Two hauls were then made in Aberdeen Bay in the neighbourhood of Newburgh, in from 5 to 13 fathoms. In the first, for four hours and ten minutes, 384 fishes were caught, of which 242 were marketable and 142 unmarketable. Haddocks, plaice, whittings, and dabs formed the greater part of the catch, most of the haddocks being unmarketable. In the next drag 572 fishes were obtained, 274 being marketable, 5 of which were turbot. The particulars of these two hauls, the time of fishing being eight hours and fifteen minutes, are as follows :—

	Had-dock.	Whit-ing.	Gur-nard	Turbot.	Plaice.	Lemon Dab.	Commen Dab.	Long Rough Dab.	Angler.
I.	41	48	.	5	364	3	55	.	.
II.	103	21	13	.	.	.	298	3	2
Total	144	69	13	5	364	3	353	3	2

The statistics showed that the total quantity of fish landed at the market amounted to 65½ cwts., as follows :—

Cod.	Codling.	Ling.	Hake.	Haddock.	Turbot.	Brill.	Lemon Dab.	Plaice.
14½	3	1½	½	21½	½	½	½	18
			Dabs.	Witch.	Skate.	Cat-fish.		
			½	½	2	½		

IV.

Early in November another series of hauls was made in Aberdeen Bay by the "Ocean Bride." The first, for three and a quarter hours, was between the "Black Dog" and Newburgh, in 11 to 13 fathoms, and 689 fishes were caught, of which 422 were marketable and 267 unmarketable. Haddocks numbered 185, all but 15 large enough to go to market ; there were 73 plaice, 163 common dabs, 9 cod, 63 codling, 154 whiting, as well as a halibut and 3 turbot. Other five recorded hauls were made in the same locality in from 4½ to 13 fathoms, and the total number of fishes taken in the twenty-one hours and forty minutes of actual fishing was 2398, 1410 being marketable and 988 unmarketable. The particulars are given in the following Table :—

	Cod.	Codling.	Had-dock.	Whiting.	Gurnard.	Ling.	Coal-fish.
I.	62	181	685	69	.	1	2
II.	.	9	66	293	9	.	.
Total	62	190	751	362	9	1	2

[Continued.

	Halibut.	Turbot.	Plaice.	Common Dab.	Long Rough Dab.	Skate.	Angler.
I.	2	3	346	59	.	.	.
II.	.	.	.	230	76	293	12
Total	2	3	346	239	76	293	12

V.

The next series of trawling observations was made in the Moray Firth in the latter part of November, the trawler employed being the “Braconhill.” Burghead Bay was first visited, and three hauls were taken there on the 21st and 22nd in from 5 to 15 fathoms. In the first the number of fishes secured in the three hours and fifteen minutes the drag lasted was 462, of which 421 were marketable. The bulk of the catch consisted of plaice, of which 405 were caught, mostly small and mediums. Haddocks were scarce, only 28 being taken, and they were all unmarketable. Seven brill were also included in this catch. In the next haul, for three hours and fifty minutes, 1385 fishes were obtained, 1145 being marketable and 240 unmarketable. The number of plaice was large, viz., 1072, and they were all marketable, chiefly small and mediums. Four turbot and 12 brill were also caught in this drag. The other two hauls on this ground were equally productive, the catches totalling 1307 and 1493 fishes respectively, the greater proportion being marketable, and consisting chiefly of plaice.

The vessel then steamed to the so-called “witch-ground,” off Cromarty, and made a haul there in 27 to 30 fathoms for an hour and ten minutes with the small-meshed net around the cod-end; there was a strong breeze from the N.N.E., with snow showers and a rough sea. The number of fishes in the cod-end was 310, of which 67 were marketable; they chiefly consisted of whittings, witches, and dabs. The small-meshed net contained the following fishes:—

Codling, - - -	2	Long Rough Dab, - -	152
Haddock, - - -	17	Common Dab, - - -	94
Whiting, - - -	349	Witch, - - -	21
Norway Pout, - -	83	Gurnards, - - -	4
Hake, - - -	4		

Two other hauls were taken in this locality, the catches of which were not recorded; in the second the net was split and the ground rope broken, and the vessel lay to till morning and then returned to Burghead Bay, where a series of hauls were made. In the first of these, in from 7 to 19 fathoms, for four hours and a half, 1139 fishes were secured, of which 939 were marketable and 200 unmarketable. The plaice numbered 917, and the haddocks 155, all of the latter except five being too small for market; a turbot and 11 brill were also taken. In the next drag 1049 fishes were taken in the four hours and ten minutes it lasted, almost all marketable, viz., 998, and mostly plaice, which numbered 962. In the third drag, for four hours and fifteen minutes, 1283 fishes were captured, 1199 of which were marketable; and in a fourth haul 1339 were taken, 1262 being marketable, plaice again forming the greater portion of the catch, which also included 7 turbot 18 brill.

The vessel then proceeded to the Dornoch Firth, where three hauls were made. One of these was not recorded, and the first of the others was a small-meshed drag, which lasted for one hour and was made in from 6 to 10 fathoms, a moderate breeze blowing from the W.S.W. with rain, and the sea being smooth. In the cod-end there were 396 fishes, 284 of which were marketable and 112 unmarketable. Most of the catch consisted of plaice, but there were also 57 large and medium haddocks, a cod, and a few dabs. The contents of the small-meshed net were as follows :—

Codling, - - -	26	Long Rough Dab, -	1
Whiting, - - -	408	Plaice, - - -	30
Common Dab, - -	127	Herring, - - -	573
Witch, - - -	1	Sprat, - - -	79

The second drag, in about 8 fathoms for four hours, gave 1650 fishes, of which 1594 were marketable. The catch included 1252 plaice, 5 cod, 348 haddocks, a halibut, and 2 turbot. The two drags, representing five hours' fishing, yielded 2046 fishes, 1878 being marketable. In this total the plaice numbered 1481 and the haddocks 409. The marketable and unmarketable fishes are as follows :—

	Cod.	Cod-ling.	Had-dock.	Whit-ing.	Coal-fish.	Hali-but.	Tur-bot.	Plaice.	Lemon Dab.	Com. Dab.	Thorn-back.
I.	6	7	389	.	1	1	2	1,457	3	12	.
II.	-	10	20	31	.	.	.	24	.	80	3
Total	6	17	409	31	1	1	2	1,481	3	92	3

Both among the haddocks and the plaice the proportion of the small fishes was inconsiderable compared with some other hauls. The numbers of the different classes were as follows :—

	1st	2nd	3rd	4th	Unmarketable	Total.
Haddock,	223	166	—	—	20	409
Plaice,	4	426	307	720	24	1481

Before leaving the Firth some further hauls were made in Burghead Bay on the 26th. In the first of these, in from 6 to 19 fathoms and for four hours and a half, the number of fishes caught was 1017, 922 being marketable. Haddocks were sparingly represented, the bulk of the catch consisting of plaice—857—and 2 turbot, 17 brill, and 2 witches were also included in the total. In the next haul, in 16 to 20 fathoms, for four hours and twenty minutes, 1013 fishes were taken, 909 being marketable; they consisted mostly of plaice. The third haul was not completely recorded; it included nine baskets of plaice.

In the ten hauls made in Burghead Bay during this trip, the duration of actual fishing being being forty hours and five minutes, the total number of fishes obtained was 11,487, or an average of 2865·6 per ten hours' fishing the marketable numbered 10,038, the average per ten hours being 2504·4, and the unmarketable amounted to 1449, the

average being 361·2. The particulars are given in the accompanying Table :—

	Cod.	Codling.	Had-dock.	Whit-ing.	Coal-fish.	Gur-nard.	Halibut.	Tur-bot.	Brill.
I.	19	12	12	-	1	-	3	19	121
II.	-	59	340	160	-	144	-	-	-
Total	19	71	352	160	1	144	3	19	121

	Plaice.	Lemon Dab.	Black Sole.	Witch.	Com. Dab.	Long Rough Dab.	Skate.	Angler.
I.	9,404	20	1	20	378	-	28	-
II.	56	-	-	-	644	10	9	27
Total	9,460	20	1	20	1,022	10	37	27

The number of haddocks, it will be observed, was very small, and the remark is true indeed of round fishes generally. The ten drags yielded only one dozen marketable haddocks, the same number of codlings, while all the whittings were unmarketable. Flat-fishes, on the other hand, were abundant. Nineteen turbot, 121 brill, 3 halibut, and 9404 plaice were taken to market, as well as 20 lemon dabs, a black or common sole, and some others. A considerable proportion of the plaice consisted of mediums, as the following statement shows :—

	1st	2nd	3rd	4th	Unmarketable	Total.
Plaice,	91	4110	5090	113	56	9460

In Aberdeen Bay, on the 28th, a haul was taken with the small-meshed net around the cod-end, in 19 to 21 fathoms, the drag lasting for one hour and fifteen minutes. The catch was a very poor one, consisting of only 18 marketable fishes and 61 unmarketable, in the cod-end, or 79 altogether, and it comprised 30 haddocks and 31 whittings, and only 6 plaice. The small-meshed net contained the following :—

Codling,	-	-	48	Common Dabs,	-	53
Haddock,	-	-	46	Long Rough Dabs,	-	11
Whiting,	-	-	806	Herring,	-	1
				Sprats,	-	6

The total quantity of fish landed as a result of this trip amounted to 183½ cwts., as follows :—

Cod.	Codling.	Haddock.	Turbot.	Halibut.	Brill.	Lemon Dab.	Plaice.	Dabs.
9½	1½	6½	1½	½	4		146½	3½
			Witch.	Conger	Skate.			
			3½	½	5			

VI.

In the early part of December another series of trawlings was made, the steam trawler employed being the "Loch Lydoch." In the Moray Firth Burghead Bay was the first place visited. A haul there on the 6th, in from 16 to 4½ fathoms, but chiefly under 7, for four hours, gave 1007 fishes, of which 849 were marketable and 158 unmarketable. Plaice formed the bulk of the catch; 747 were obtained, all but 9 being marketable. There were also 8 cod, 4 turbot, 21 brill, and 3 lemon dabs. Only 20 haddocks were taken, and they were all unmarketable. The plaice amounted to nine level basketfuls, five consisting of mediums, one of large, and the rest thirds. The weather was fine, the sea calm, with a gentle westerly breeze.

The second drag, for four-and-a-quarter hours, was made in the same place and in the same depths, and the catch amounted to 1082 fishes, 939 being marketable and 142 unmarketable. The number of plaice caught was 853, all being marketable; 11 were large, 291 medium, and 551 small. Included in the catch were 18 cod, 2 turbot, 13 brill, and a cat-fish. Haddocks were very scarce, only seven being taken, one of which was marketable. In the same locality the third drag, for four hours and ten minutes, in from six to nine fathoms, yielded 1120 fishes, of which 950 were marketable and 170 unmarketable. There were 860 plaice, all marketable, twelve being large, 318 medium, and 530 small. There were also ten brill, twelve cod, and thirty-two haddocks, of which only six were marketable.

The next haul extended into deeper water, viz., twenty fathoms, but was mostly about eight or nine, and in the four hours and five minutes it lasted 953 fishes were taken, of which 897 were marketable and 56 unmarketable. The catch included 823 plaice, all marketable, two turbot, nineteen brill, a cod, and a few dabs. There were twenty-one haddocks, all unmarketable.

A drag for an hour with the small-meshed net around the cod-end of the trawl yielded in the latter 208 fishes, plaice again predominating.

The small-meshed net contained 329 fishes, as follows:—

Codling, - - -	8	Sand-eel, - - -	6
Whiting, - - -	134	Herrings, - - -	129
Common Dab, - -	18	Sprats, - - -	23
Long Rough Dab, -	1		

The vessel then steamed to the Dornoch Firth, where a few hauls were made. The first, with the small-meshed net around the cod-end, lasted for an hour, and was made in from 4 to 9 fathoms. The number of fish taken was 213—178 being marketable and 35 unmarketable. The catch included 1 cod, 3 codling, 18 haddocks, all marketable, 156 plaice, and a few others.

A few other hauls were made around a dan, placed in 12 fathoms. In the first of these, the drag lasting four hours and twenty minutes, 934 fishes were secured, of which 811 were marketable. The catch included 737 plaice, 55 of which were unmarketable, and 117 haddocks, all but ten of which were marketable. The next haul was not completely recorded; it included two baskets of medium and one of small plaice, one basket of large and one of small haddocks. Another drag made in from 8 to 12 fathoms, and lasting for five hours, yielded 850 fishes, 742 being marketable and 108 unmarketable. Plaice formed the bulk of the catch, 746 being taken, of which 33 were unmarketable; only 7 haddocks

were taken in this drag, all marketable. In the three recorded hauls, the duration of fishing being ten hours and twenty minutes, 1999 fishes were caught, 1733 being marketable and 266 unmarketable. The proportion of large and small haddocks and plaice was as follows :—

	1st	2nd	3rd	4th	Unmarketable	Total
Haddocks,	4	18	110	—	10	142
Plaice,	—	406	498	640	95	1639

The details as to the marketable and unmarketable are these :—

	Cod.	Cod-ling.	Had-dock.	Whit-ing.	Gur-nard.	Plaice.	Lemon Dab.	Meg-rim.	Com. Dab.	Sole-nette.	Thorn-back.
I.	3	5	132	1	-	1,544	1	1	35	-	9
II.	-	26	10	25	3	95	-	-	88	1	18
Total	3	31	142	26	3	1,639	1	1	125	1	27

Some further drags were made in Burghead Bay with, on the whole, good catches of fish. The depth was usually from 6 to 9 fathoms, the length of the haul about four hours, and the aggregate number of fishes for a haul varied from 631 to 1027. Plaice formed the greater part of the catches, but there were also a good few cod, turbot, and brill, while haddocks remained singularly scarce. The aggregate numbers in the eleven recorded hauls here during the voyage—the duration of the fishing being forty-two hours and twenty minutes—were 9253 fishes, 8032 marketable and 1221 unmarketable. The following Table shows the proportion of marketable and unmarketable of each kind :—

	Cod.	Codling.	Had-dock.	Whit-ing.	Cat-fish.	Gur-nard.	Coal-fish.	Halibut.
I.	71	37	42	-	1	-	1	1
II.	-	172	137	148	-	15	-	-
Total	71	209	179	148	1	15	1	1

	Turbot.	Brill.	Plaice.	Lemon Dab.	Witch.	Common Dab.	Long Rough Dab.	Flounder.
I.	15	136	7,530	8	17	530	-	2
II.	-	-	50	1	-	623	32	-
Total	15	136	7,580	9	17	1,153	32	2

	Thorn-back.	Sandy Ray.	Sand Eel.	Sprat.	Angler.	Cottus Scorpius.	Herring.
I.	-	1	-	-	-	-	-
II.	6	16	1	1	41	1	11
Total	6	17	1	1	41	1	11

It will be observed that only 179 haddocks were taken, and of these only 42 were marketable, or a proportion of about one haddock per hour's fishing. None of the 148 whittings caught were marketable, while 37 out of 209 codlings were marketable. There were 15 turbot and 136 brill, all of them being marketable. The bulk of the marketable fishes consisted of plaice, of which altogether 7580 were taken, all but 50 being marketable. The proportion of large and small among the plaice was as follows :—

1st	2nd	3rd	4th	Unmarketable	Total
62	3222	3854	394	50	7580

The vessel then steamed to Smith Bank, where a haul was made for an hour with the small-meshed net around the cod-end in from 19 to 22 fathoms. In the trawl-net there were only 28 fishes, viz., a codling, a brill, and 26 plaice, all marketable. The small-meshed net contained 1968 fishes, belonging to ten species, as follows :—

Codlings,	-	-	-	53	Sand-eel,	-	-	1
Haddock,	-	-	-	4	Armed Bullhead	-	-	1
Whiting,	-	-	-	1861	<i>Liparis</i> ,	-	-	3
Gurnard,	-	-	-	2	Herring,	-	-	12
Common Dab,	-	-	-	27	Sprat,	-	-	4

On the way to port a few hauls were taken in Aberdeen Bay, a strong N.E. wind blowing, with a rough sea and heavy rain. The first drag was for an hour, in from 17 to 19 fathoms, in the northern part, off the quarries, and the small-meshed net was used. The trawl contained 143 fishes, of which 103 were marketable. The catch comprised 6 cod, 54 codling, all marketable, 41 plaice, and a few others. In the next drag in the same locality, for four hours and five minutes, in from 17 to 19 fathoms, 182 fishes were caught, of which 136 were marketable and 46 unmarketable. Among the former were 19 cod, 24 codling, 2 halibuts, and 78 plaice. In neither haul were any haddocks taken.

The following Table shows the proportion of the marketable and unmarketable fishes :—

	Cod.	Cod-ling.	Whit-ing.	Hali-but.	Plaice.	Com. Dab.	Long Rough Dab.	Thorn-back.	Grey Skate.	Ang-ler.
I.	25	78	-	2	119	12	-	-	2	1
II.	-	5	10	-	-	24	10	33	4	-
Total	25	83	10	2	119	36	10	33	6	1

The total quantity of fish landed by this vessel, as a result of its trip, amounted to 118 $\frac{7}{8}$ cwts., as follows :—

Cod.	Codling.	Haddock.	Turbot.	Halibut.	Brill.	Lemon Dab.
16 $\frac{5}{8}$	3	4	1	$\frac{1}{4}$	3	$\frac{3}{8}$
		Plaice.	Dabs.	Skate.	Catfish.	
		86 $\frac{1}{4}$	3	$\frac{1}{2}$	$\frac{1}{4}$	

A TRIP TO THE FAERÖE GROUNDS.

In April a trip to Faeröe was made by Mr. W. Chalmers, on board the steam trawler "Star of the Wave," and records were taken by him and the skipper, Mr. S. Caie, which are here included. The vessel left Aberdeen on the morning of the 22nd and arrived at Faeröe early in the morning of the 24th, the voyage occupying forty and a half hours. Nearly all the fishing took place to the south-east of Fuglö, in deep water, and the weather was stormy, the vessel being compelled to lay to for twelve hours. The first haul was made about six and a half miles off, Fuglö bearing N.W.; the trawl was dropped in 55 fathoms and hauled after four hours in 73 fathoms. The catch comprised 1048 fishes, of which all but three were marketable. Here it may be said that the offal or unmarketable fishes in the drags at the Faeröe deep water grounds bear a very small proportion to the marketable fishes, and offer a contrast to what usually obtains in, say, the Moray Firth. In this haul the number of codlings was very large, viz., 520, all of them marketable; there were 5 cod, a ling, a tusk, 16 halibuts, 400 haddocks, mostly large and all marketable, 30 lemon dabs and 9 plaice, as well as 21 cat-fish, and a few others. In the next haul, on the same ground, the net was split, and a complete record was not made of the catch. It included, however, a basket of codling, 1 cod, 906 haddocks (all but 1 marketable), 4 halibuts, a ling, 11 cat-fish, 18 plaice, and 28 lemon dabs; there were 15 offal fish. The next drag, also on the same grounds, in from 53 to 57 fathoms, for four hours, yielded 898 fish, all but 24 marketable. They consisted of the same kinds, codling being less numerous, and the haddocks numbered 778, all of them being marketable.

A number of hauls were made on this ground on the 24th and 25th, in some of which the net was split, and in one the cod-end (of single twine on this occasion for experimental purposes) gave way and most of the catch was lost. In one of the drags, for four hours, 15 baskets of large haddocks, one of mediums, and one and a half of smalls were taken, with about 200 cod, and a number of halibut, plaice, and ling. On the afternoon of the 25th the weather was so bad that the vessel had to run for shelter, and the next forenoon fishing was resumed about 15 miles off Viderö in 60 to 67 fathoms, but with poor results, the net being split and a gale blowing. In the evening, fishing off Fuglö was resumed, and a number of hauls were taken in from 48 to 75 fathoms, haddocks, codlings, and cod forming the bulk of the catches.

Altogether the vessel made 29 hauls in the Faeröese waters, leaving for Aberdeen on the morning of the 30th, and arriving in the port early on the morning of May 2. In some of the hauls the net was torn, and in other cases the catch was not completely enumerated. In 17 recorded hauls, the aggregate time of fishing being sixty-seven hours and twenty minutes, 13,932 fishes were captured, of which 13,767 were marketable and 164 unmarketable. The ratio per ten hours of fishing was 2069·2 fishes, the marketable being 2044·8 and the unmarketable 24·4 per ten hours. The total number of the principal species taken in these hauls, and the ratio per ten hours' fishing, are given in the following Table:—

[TABLE.]

	Cod.	Cod-ling.	Ling.	Coal-fish.	Had-dock.	Whit-ing.	Cat-fish.	Tusk.
No. .	538	3,275	12	77	8,846	5	175	3
Average	79·7	486·4	1·8	11·4	1312·9	0·74	26·0	0·44

	Halibut.	Plaico.	Lemon Dab.	Common Dab.	Turbot.	Megrim.	Angler.
No. .	165	191	331	180	4	1	61
Average	24·5	28·4	49·0	27·0	0·6	0·15	9·0

The number of cod in any of the drags varied greatly—from *nil* to 160 ; the number of codling ranged from 50 to 520 and 484, and in these hauls they were all marketable. The total of haddocks in the different hauls varied from 242 to 1153, and they were all marketable. Cat-fish were got in each of the 17 drags, their numbers varying from 4 to 21 ; halibut were taken in 16 of the hauls, the numbers ranging from *nil* to 34 in the different hauls. Plaice were also got in each haul, the numbers varying from 4 to 27. Among lemon dabs, also taken in each of the drags, the numbers varied from 2 to 46.

At already stated, the proportion of the unmarketable fishes from these grounds is small, and the sizes of the marketable are also large. The sizes of the haddocks and plaice taken were as follows :—

	1st	2nd	3rd	4th	Unmarketable	Total.
Haddock, 5,999	535	1,944	—	—		8,478
Plaice, 175	16	—	—	—		191

The haddocks in one of the hauls referred to, 362 in number, were not classified ; and among the “ 1st ” in the above list are a number of “ extra large.”

One haul was made for thirty minutes with a small-meshed net around the cod-end, in from 58 to 63 fathoms, south-east of Fuglo. The catch in the cod-end numbered 114 fishes, all marketable, comprising 1 cod, 48 codling, 49 haddocks, 2 cat-fish, 1 halibut, 2 plaice, 3 lemon dabs, 7 common dabs, and 1 thornback. Only 9 fishes were in the small-meshed net, viz. 3 haddocks, 253, 257, and 271mm. ; 1 common dab, of 159mm., and 5 sand-eels.

Among the halibut were some small ones which were brought back and measured ; they ranged from 220mm. to 312mm. (eight and three-quarter inches to twelve and a quarter inches), and were 7 in number.

The cod were stated to be spawning, and the haddocks far advanced. The quantity of the roes of haddocks and cod obtained and brought to market was ten and a half boxes.

According to the market statistics, the total quantity of fish landed from this voyage amounted to 391½ cwts., as follows :—

Cod.	Codling.	Ling.	Tusk.	Saithe.	Haddock.	Halibut.	Lemon Dab.	Plaice.
111½	84	6	½	16	112	10½	6	14
			Dabs.	Skate.	Cat-fish.	Monk.		
			½	2	26	2		

TRAWLING INVESTIGATIONS—TABLE I.

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TRAWLING

I.

Part III.—Twenty-third Annual Report
TRAWLING INVESTIGATIONS—TABLE I.

TRAWLING

I.

Loca.	Date.	Temperature.		
		Air.	Surface.	Bottom.
Sand- ie Bay.	1904. Jan. 20.	45.1	47.6	47.7
Off Ord Caith- ness.	Jan. 21.	42.1	48.2	46.5
"	"	"	"	"
"	"	"	"	"
"	"	"	"	"

Wind S.W. ; very
equally at night.

TRAWLING

L.

TRAWLING INVESTIGATIONS—TABLE I.

TRAWLING INVESTIGATIONS—TABLE I.

TRAWLING

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TRAWLING INVESTIGATIONS—TABLE I.



TRAWLING INVESTIGATIONS—TABLE I.

20

1881

1882

1883

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FASTER INVESTIGATIONS—TABLE I.

TRAWLING INVESTIGATIONS—TABLE I.

1887.

1888.

1889.

1890.

Part III.—Twenty-third Annual Report
TRAWLING INVESTIGATIONS—TABLE I.

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TRAWLING INVESTIGATIONS—TABLE I.

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TRAWLING INVESTIGATIONS—TABLE I




TRAWLING INVESTIGATIONS—TABLE I.

1874

1875

1876

1877

1878

1879

1880

TRAWLING INVESTIGATIONS—TABLE I.

Place.	Date.	Temperature.			Depth in Fms.	Time Trawl Down.		Fish Caught.				Remarks.
		Air.	Surface.	Bottom.		Shot.	Hauled.	Name.	No. taken to Market.	No. thrown Over- board.	Total No.	
Burghead Bay.	1904. Nov. 25.	5 to 12	3.45 a.m.	8.0 a.m.	Cod, ..	8	..	8	W.S.W gen breeze ; sea r
								Codling, ..	7	2	9	
								Haddock ..	..	19	19
								Whiting, ..	..	14	14
								Grey Gurnard, ..	..	7	7
								Turbot, ..	7	..	7	
								Brill, ..	18	..	18	
								Plaice (1), ..	10	..	..
								" (2), ..	505	..	..
								" (3), ..	328	..	..
									1133	..	1133	
								Lemon Dab, ..	5	..	5	
								Witch, ..	1	..	1	
								Com. Dab, ..	83	31	114	
								Angler, ..	..	4	4
Dornoch Firth.	"	6 to 10	11 30 a.m.	12.30 p.m.	Cod, ..	1	..	1	Wind W.S. moderate br sea smooth ; r
								Codling, ..	1	8	9	
								Haddock (1), ..	32	..	..
								" (2), ..	25	..	..
									57	4	61	
								Whiting, ..	..	31	31
								Plaice (2), ..	57	..	..
								" (3), ..	67	..	..
								" (4), ..	89	..	..
									213	16	229	
								Com. Dab, ..	12	50	62	
								Thornback, ..	..	3	3
									284	112	396	
"	"	8	5.0 p.m.	9.0 p.m.	Cod, ..	5	..	5	Weather fine.
								Codling, ..	6	2	8	
								Coal-fish, ..	1	..	1	
								Haddock (1), ..	191	..	..
								" (2), ..	141	..	..
									332	16	348	
								Halibut, ..	1	..	1	
								Turbot, ..	2	..	2	
								Plaice (1), ..	4	..	..
								" (2), ..	360	..	..
								" (3), ..	240	..	..
								" (4), ..	631	..	..
									1244	8	1252	
								Lemon Dab, ..	3	..	3	
								Com. Dab, ..	..	30	30
Burghead Bay.	Nov. 26.	6 to 19	5.0 a.m.	9.30 a.m.	Codling,	7	7	
								Haddock, ..	..	15	15
								Whiting, ..	..	22	22
								Grey Gurnard, ..	..	1	1
								Turbot, ..	2	..	2	
								Brill, ..	17	..	17	
								Plaice (1), ..	12	..	..
								" (2), ..	417	..	..
								" (3), ..	385	..	..
								" (4), ..	43	..	..
									857	..	857	
								Witch, ..	2	..	2	
								Lemon Dab, ..	2	..	2	
								Com. Dab, ..	37	50	87	
								Skate, ..	5	..	5	
									922	95	1017	

TRAWLING

TABLE I.

Loc.	Date.	Temperature.			Depth in Fms.	Time Trawl Down.	
		Air.	Surface.	Bottom.		Shot.	Hauled.
Arghead wy.	1904. Nov. 26.	..	..	..	16 to 20	3.20	7.40
..	Nov. 26 and 27	..	..	..	6 to 16	8.15 p.m.	12.30 a.m.
Arden wy.	Nov. 28.	..	..	..	19 to 21	10.0 a.m.	11.15 a.m.
Arghead wy.	Dec. 6.	43.5	45.0	45.2	4½ to 16	2.0 p.m.	6.0 p.m.

TRAWLING

TABLE I.

Place.	Date.	Temperature.			Depth in Fms.	Time Down Start.
		Air	Surface	Bottom.		
Burghead Bay.	1904. Dec. 6.				4½ to 16	6.32
"	Dec. 7.				6 to 9	3.35 a.m.
"	"				7½ to 20	8.5 a.m.
"	"	38.3	44			

TRAWLING INVESTIGATIONS—TABLE I.

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TRAWLING INVESTIGATIONS—TABLE I.

TABLE I.

TABLE I.

TABLE I.

TABLE I.

TABLE I.

TRAWLING INVESTIGATIONS—TABLE 1.

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TRAWLING INVESTIGATIONS—TABLE I

TRAWLING INVESTIGATIONS—TABLE I.

TRAWLING INVESTIGATIONS—TABLE I.

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TRAWLING

TABLE I.

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TRAWLING INVESTIGATIONS—TABLE I.

500 200

100 100

100

100 100

TRAWLING INVESTIGATIONS—TABLE I.





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II.—A CONTRIBUTION TO THE LIFE-HISTORY OF THE
LOBSTER (*HOMARUS VULGARIS*). By H. CHAS.
WILLIAMSON, M.A., D.Sc., Marine Laboratory, Aberdeen.

(PLATES I.—IV.)

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EXPERIMENTS IN LOBSTER-CULTURE.

In the summer of 1902 the Fishery Board instructed me to carry out some experiments in the culture of lobsters and crabs. It was intended that the young lobsters hatched out at the Laboratory should be liberated on the north coast of Aberdeenshire, in the neighbourhood of Fraserburgh. In order to obtain a supply of larvæ a number of berried hen lobsters were procured from Girvan and Dunbar in June and July. Eight were sent from Girvan and ten from Dunbar; one was captured in the Bay of Nigg. One of the Dunbar lobsters arrived on August 2nd. The lobsters were conveyed by rail, packed, in some cases, in straw, in other cases in dripping seaweed. The latter method was much the better, the lobsters, after their eight to twelve hours' confinement, being unpacked in a fresh and lively condition. Some of those packed in straw succumbed. In 1904 the stock of berried lobsters were all packed in wet seaweed, and none died in transit.

No special apparatus, with the exception of two tin boxes, was made for the experiment. A temporary arrangement of the hatching apparatus (Dannevig's), used for the eggs of the plaice, proved successful on the whole. The eggs were already far advanced.

An attempt was made to hatch the eggs detached from the parent lobster in one or two cases where the latter had died during transport to Aberdeen. A sheet-iron box, which fitted into one of the compartments of the hatching apparatus, and which was arranged with a perforated bottom through which the water entered, to escape by the top of the box through a grating, was employed; but a considerable death-rate ensued, and the eggs were attacked by a fungus. None of the eggs hatched out. It was decided to allow the eggs to remain attached to the parent until they hatched. All that was necessary then was to keep the adults in a suitable tank and to make arrangements whereby the larvæ, as they hatched out, could be captured and removed to suitable boxes where they would be under control.

Fullarton adopted the method of keeping the berried females in confinement, in an open pond, until the eggs hatched; but in his experiments carried out in 1895 the larvæ were allowed to escape to the sea as they were hatched. In the present case the young lobsters had to be retained. The arrangement was as follows. The berried hens, fourteen in number, were kept in a wooden tank measuring about 8 feet by 4 feet 6 inches by 2 feet deep. The water supply entered at the bottom of the box, and the outflow took place from the surface of the water. The overflow water was led into the hatchery and distributed into the hatching apparatus. As the little lobsters hatched out they were carried down to the hatchery and caught and detained in the hatching boxes.

In order that a large number comparatively of lobsters be kept in a small area, it is necessary that they each be provided with a hole or pen for shelter. The wooden tank in which the adults were confined was prepared in the following manner. A plank of wood about 7 inches wide was hinged by means of large fencing staples to the side of the wooden tank. When horizontal in position it was about 4 or 5 inches above the bottom. The space beneath this shelf was divided off by means of bricks set on edge into as many compartments as were required; in this case seven. The shelf rested on the bricks, and when the tank was filled it was kept down by a suitable weight, some stones or bricks. One shelf was put on each long side. This arrangement permitted of ready examination of the lobsters, as when the superincumbent stones were removed the shelf floated up, revealing the lobsters. They remained there, then, in apparently suitable conditions. Each lobster stuck to its pen, its body hid by the shelf, and its projecting antennæ alone betraying its presence. Only one lobster died from injuries received through fighting with the other inhabitants of the tank. The large chelæ were not tied.

The young hatched out in batches. The eggs of one female do not all hatch simultaneously, but over a period. In two cases recorded by Herrick, a week elapsed from the time the first larva appeared until all were hatched out. Fullarton found the time necessary for hatching a single brood varied from a week to three weeks, or even longer. The aeration of the eggs attached to the abdominal feet of the female is assured in the following manner. The lobster is seen every now and then with its abdomen stretched out to its full extent and resting on the inturned edge of the telson. The swimmerets are meanwhile gently waved backwards and forwards, in this way aerating the eggs and tending to cleanse them. When the eggs are ready to hatch this facilitates the escape of the larvæ. This action was noticed by Coste. The hatching of the lobster eggs at Brodick, Fullarton states, occurred in July, August, and September, with a maximum in August.

The first young lobsters were observed in the Laboratory, Bay of Nigg, on July 11th; they had then reached the hatching apparatus. They apparently hatch during the night, as each morning there was a fresh addition to the stock. The little lobsters were in the first zoëa stage (fig. 66). They were kept in boxes having sieve bottoms, which were placed in the top compartments of a hatching apparatus. They measured about 1 foot by 1 foot by 1 foot, and were painted black. They received light from above only. The number of larvæ kept in one box varied, but not more than twenty were knowingly confined together. They were kept in the top compartments in order that they might obtain a share of the food that was being brought in by the water supply, *e.g.* copepoda, diatoms, and larvæ of invertebrates. The water was not filtered. It flowed into the box by a spout and out by the sieve bottom, the arrangement which is followed in hatching the eggs of plaice and cod.

The lobsters, immediately after being hatched, swam actively about, chasing copepoda and any small white particles moving in the water. The two species of copepods most common in the water were determined by Dr. Scott. A red copepod was *Temera longicornis*; a white one was *Eurytemera affinis*. They were both small.

During the zoëa stages, when the lobster is wholly pelagic, that is to say before the pereopods function as walking legs, a period of, roughly, three weeks, it swims with its body bent in a quadrant shape, having the head and thorax lying horizontal, or inclined slightly downwards, and the abdomen and tail directed downwards. If it spies a copepod beneath it swims directly down for it in a circling, sort of corkscrew path, and follows up its prospective victim, when it escapes with a smart dart off for a distance of an inch or two. The pursuit may last for a little time, and now and then the lobster catches and devours the copepod. When the copepods are swimming above them they also detect them and swim directly for them. They also notice them when in front of them and on the same level. The copepods are to be seen on the side of the box, and the young lobsters go poking about the side after them.

The larval lobster, when undisturbed, swims forward at a uniform speed by means of the exopodites of the pereopods, turning sharply to this side or to that to seize any object that attracts its attention, and which it will pursue till it loses sight of it or has its attention distracted by another form. When surprised it jerks backward by means of its abdomen and telson.

The young lobsters were usually close to the surface of the water. No food was provided regularly for them, except what was brought in with the water supply. On a few occasions a little of the liver of the crab (*Cancer pagurus*) was supplied them. They pursued the little white portions as they fell through the water, usually catching them before they reached the bottom. They ate up the live zoëæ of *Cancer pagurus* when these were poured into the box.

While the lobster in the zoëa stages no doubt eats dead organisms, as Cunningham relates, it is much more active in the pursuit of living animals. It follows, from the fact of its pelagic existence, that it must feed on living forms.

The lobsters were kept for varying periods. When set free they were mostly in the second and third stages; some were in the first stage. A few were reared to the megalops stage on the food in the water supply. The total number set free was about 3000. They were distributed as follows:—

August 6, 1902.—1000 larvæ set free a little over 1 mile north of Fraserburgh.

August 7, 1902.—1000 larvæ set free about $\frac{1}{2}$ mile off Cairnbulg

August 19, 1902.—1000 larvæ set free about $\frac{1}{2}$ mile off St. Combs.

The fry were conveyed in large glass (sulphuric acid) carboys by rail to Fraserburgh. All the lobster fry (1000) were on each occasion stowed in one carboy. The number of fry in the first consignment was counted, and from that datum the numbers in the subsequent lots were deduced.

No special cooling preparations were found to be necessary for the journey. Experiments were made to test the effect of a possible rise in the temperature of the water during the transportation. The temperature of the sea-water in the hatchery was 12.5° C. A few lobster fry were put into a jar containing half-a-gallon (= $\frac{2}{3}$ litre) of water. The jar was heated slowly until the water reached a temperature of 20° C; it was then allowed to cool. Next day the lobsters were, with two exceptions, all lively; two had succumbed.

For the journey to Fraserburgh the larvæ were packed at 3.15 p.m., and were set free at 7.15 p.m., at which time they were all quite lively.

The vitality of the young lobster under certain conditions is remarkable. Herrick kept them alive in small flat dishes, without change of the water, from one to four days at a time, or until they moulted to the second stage. A case in point occurred at the Laboratory. After one of the journeys to Fraserburgh a few larvæ had been left in the dregs of water in one of the carboys. They were discovered 10 days later, and were then alive and active. Two small crabs (*Carcinus mænas*) were kept for a week in a little glass cell without change of water, and apparently suffered no ill-effects.

There was a considerable mortality among the larval lobsters when in the hatchery. As has been so often noted, a proportion of the deaths occurred during moulting. The dead lobsters were sometimes partly eaten. No case was seen of one zoëa attacking and killing another, such as Herrick witnessed. A case of cannibalism was noticed in the megalops stage. One megalops was seen eating the tail of another which was still alive. The telson and part of the abdomen had been eaten off when discovered. A cause of considerable mortality is probably starvation. It is difficult to supply suitable and sufficient food.

All the lobster eggs were hatched out by September 10, 1902.

THE REARING OF LOBSTERS.

There are two well-marked stages in the life of the lobster fry: these are (1) the first swimming stage, when just hatched (fig. 66, pl. iv.), and (2) the stage when it for the first time takes on the form, and, to a certain extent, also the habits, of the adult (fig. 72, pl. iv.). The former is the first zoëa stage, the latter is the megalops stage. Previous to the first zoëa stage there is the protozoëa, a stage of short duration. The lobster has been described as issuing from the egg as a protozoëa. This condition was not observed by the writer. It moults very soon after, and becomes a zoëa of the first stage. R. Q. Couch was the first to figure and describe the protozoëa. He wrote as follows:—"Several of the ripest bunches of ova were taken off, and by gentle agitation many of the young escaped and swam about very freely, like those of the common crab, and some were artificially extracted to leave no doubt to rest on their parentage. Their bodies are large, stout, and of a deep blue colour, while the other parts are semi-transparent and dotted with red. The eyes are large, sessile, situated on a festoon at the lower and anterior margin of the dorsal shield, and marked at the circumference with radiating lines. The interior margin of the shield is waved, and irregularly prominent; the posterior and lateral surfaces are more remarkably so, and are rough, with minute papillary eminences; and the lower margin is marked with seven minute plaited folds, beneath the five central ones are situated five claws on either side. They are jointed as in the adult, and the anterior pair are shorter and stouter than the others, and terminate in a pair of nippers. The tail is longer than the diameter of the body, is extended and composed of five annulations. The termination is forked, but the fork is composed of two flat fan-like expansions separated by a fissure which extends nearly as high up as their articulation."

Saville Kent and Fullarton also give drawings and descriptions of this stage.

The megalops stage is one in which the lobster in its habits resembles more a prawn (*Palæmon*), as Saville Kent pointed out. The interval which exists between the first zoëa and the megalops has been filled in by a varying number of stages. Herrick, for the American lobster,

makes the period one of three zoëa stages, and between hatching and the arrival of the young at the megalops condition there elapses from eight to eighteen days. Saville Kent said that the European lobster reached the megalops stage at about the sixth cast, *i.e.* five stages precede it, *viz.* the protozoëa and four zoëa stages. A month or six weeks are occupied in arriving at the stage beyond the megalops, which I have denominated the first young stage. My own observations lead to the conclusion that the period just mentioned will very rarely be exceeded; it is probably often as short as one month. Certain larvæ which were in the zoëa condition in October and November remained for five weeks in one stage, however.

Sars illustrates three zoëa stages. Chadwick has published a description of the protozoëa, three zoëa stages, megalops, and first young stages. The time occupied by each stage, with the exception of the protozoëa, is given as a week.

Rathke says the maxillipedes and pereopods have a general resemblance to the legs of schizopods, *viz.*, Mysis, but the resemblance is lost in the fifth pereopod. In the denomination of the larval lobsters it has been customary, therefore, to refer to the early pelagic stage as the "mysis" stage. This is due to the fact that its pereopods resemble those of Mysis, in having setæ-bearing exopodites. But this is an ontogenetic, not a phylogenetic, character, as the name is apt to imply. The main swimming organ of a zoëa is the exopodite, and the number of setose exopodites is directly proportional to the size of the larva. The little elongated zoëa of the shrimp (*Crangon vulgaris*) has three pairs of exopodites in its first stage, but its increase in bulk in the third zoëa stage demands additional swimming power, and a fourth pair of exopodites appear, *viz.* attached to the rudimentary first pereopod.* In this case the exopodite is developed, and becomes functional in the third zoëa stage, whereas the chela becomes functional for the first time on the megalops stage, *i.e.* the sixth larval stage. The exopodite of the chela at the same time vanishes, while the other exopodites, those of the maxillipedes, are reduced and function no longer for swimming. In the case of the lobster larva we have to deal with a large form, which requires a powerful swimming organ. That is secured by the development of the exopodites on the pereopods, but with this difference from the shrimp, that the pereopods themselves are also functionally developed—in the form of maxillipedes. The zoëa of the lobster is provided, then, with eight maxillipedes, each of which has a setose exopodite. On the arrival of this form at the megalops stage the latter disappear or are so reduced that they are no longer swimming organs. The quadrant shape in which the body of the zoëa is bent, by concentrating the weight of the animal, has a direct relation to its propelling organs. The tiny zoëa of *Carcinus mænas* has only two pairs of exopodites. It is bent in an arc; thereby the weight is concentrated.

There, appears, then to be no valid reason for departing from the term "zoëa" for this period of the life of the lobster. And the term "megalops" is an appropriate name for the stage which is analogous as well as homologous to the megalops of the Brachyura. It is a transition stage between the zoëa and the adult.

In this country the rearing of lobsters has been carried out by Saville Kent, Cunningham, Weldon, Fowler, and Chadwick. On the Continent Captain Dannevig has done the most extensive work in this subject; lately Appellôf has carried on rearing experiments.

Many difficulties meet the experimenter in lobster-culture. Questions of the food, of the cannibalism of the larvæ, and of the mortality which

* *Vide* Williamson.

occurs during moulting all arise. Saville Kent kept the little lobsters in jars and fed them with a little minced fish; the water was changed every day. Receptacles on the intermittent syphon system were, he considered, especially well suited for lobster-rearing. Weldon and Fowler used for the food of the larvæ the yolk of a hard-boiled egg, crushed crab (*Carcinus mænas*, *Portunus depurator*), boiled liver, the contents of the tow net (at that period chiefly *Noctiluca* and copepoda), and live shrimp larvæ; they were all partially, none absolutely, successful. Cunningham usually fed the larvæ with particles obtained by crushing and pounding common shore-crabs, but he made special and careful trials of live food. Living minute animals caught in the sea in the tow-net were introduced, but none of the larvæ were seen to try to catch them. The fish larvæ and the larvæ of a shrimp were not attacked. But the fish larvæ and little shrimps, if killed before being put into the jar, were immediately seized. He concluded that the young lobsters are naturally carrion feeders, devourers of dead food, although inclined to cannibalism.

Mead found that the fry fed upon all sorts of minute organisms (copepods, diatoms, etc.), and readily ate some kinds of flesh if it was chopped into fine pieces and kept suspended in the water, where they came in contact with it. The best food was the soft parts of clams (*Mya arenaria*.) Chadwick fed the lobster fry "daily upon the finely-minced liver of the shore-crab (*Carcinus mænas*), and the edible crab (*Cancer pagurus*), and for a time they appeared to thrive on it, but at the time of the ecdyses or shell-castings many died, and comparatively few reached the 'lobsterling' [megalops] stage."

Appellôf reared the young lobster over the larval stages till the age, in one case, of seven months. A great mortality occurred owing to the inability of the larvæ to get rid of the integument when moulting. According to this zoologist, as soon as the third casting has passed, and it has reached the fourth stage [megalops], it swims, but soon goes to the bottom, and behaves like an adult. In the fifth stage the swimming power goes; they are then very sedentary.

Herrick describes a variety of food which he found in the stomachs of lobster larvæ, viz. (1) diatoms in abundance, chiefly *Navicula* and the long tangled ribbons of *Tabellaria*; (2) remains of crustacea, probably parts of young lobsters; (3) bacteria in large numbers; (4) cotton and linen fibres, and parts of algæ. "The food of the larval lobster must necessarily consist, for the most part, of minute pelagic organisms, such as copepods and crustacean larvæ. When watched in confinement they may now and then be seen giving chase to copepods, often without success. The young lobster, however, shows little discrimination in its food. It seems to snap up almost any moving object, living or dead, which it is able to seize and swallow." Herrick has stated that one difficulty arises in raising the young of the lobster in close quarters, from the fact that the young invariably preferred to feed on one another. The death-rate was, however, he considers, due in part to other causes. In this connection, an extract from the *Bulletin of the U.S. Fish Commission*, vol. xvii., 1897, p. 135, is interesting:—"During the spring and summer particular attention was paid to the food, habits, and growth of the young lobster, and much valuable information was obtained at Wood's Hole, where extensive experiments were conducted on the holding of fry during the larval stages. The experiments indicate that, under natural conditions, the young lobster is much less a cannibal than has been believed, eating his fellows only when natural food is not available."

LARVÆ—GENERAL DESCRIPTION.

The zoëæ are beautifully coloured in two predominant tints. On the dorsum, in the gastric region, the double luminous blue spot is conspicuous. Then generally all over they are pigmented blue on the dorsum of the thorax and abdomen, and yellow or red on the sides. Certain zoëæ, which to the naked eye have a slight bluish colouration, are seen, on examination with transmitted light, to have a great quantity of yellow pigment all over the body, the carapace, abdomen, and limbs, with the dorsum of the thorax and of the abdomen blue. Others are to the naked eye brilliantly coloured with dark red, which is seen by means of the microscope to be distributed similarly to the yellow in the zoëæ just described. There are different shades of yellow: some lighter, others darker. Occasionally the colouration shows to the naked eye a mixture of red with bluish purple. In 1904 most of the lobster zoëæ were red, but others were green, showing no red to the naked eye. Some were of a very pale green.

The young lobster, while it is still a zoëa, is, from its pelagic existence during a period of at least three weeks, exposed to many dangers. Its helpless condition, combined with its fairly large size, and conspicuous colouration, will, no doubt, result in its extensive destruction. Its life near the surface of the water will, however, give it, on the whole, probably a better chance of escape from small fishes than if it were swimming close to the bottom.

While it is a zoëa the lobster swims with its head bent downwards, and it attacks the food usually from above. It sees a white piece of the liver of the crab (*Cancer pagurus*) falling a good bit below it, and swims down in a spiral till it reaches it. It, however, chases copepods on a level with it, and also below it. When it is about to cast it seeks the bottom of the box. Some which were put into a glass tank kept boring away at the bottom in an endeavour to get down out of the strong light apparently.

The keen sight of the zoëa is a remarkable contrast to the purblind condition of the adult lobster.

In the megalops stage the young lobster for the first time crawls. It also swims, but now it swims forwards by means of its pleopods, with the two long chelæ held extended straight in front, in this way protecting its rostrum from any rude shock which collision with an object might produce. It also swims and floats in a manner similar to that known as "treading water," when it tries to grasp anything near the surface, and it turns round on its long axis after copepods at the surface of the water. It can also dart backwards by means of a rapid stroke of its telson, after the manner of the adult, but this in both stages usually follows surprise, and is adopted for escape. It sinks whenever it ceases using its swimmerets or telson. The megalops swims more than the later stages. It seems to support itself more easily in the water than they do. Its method of swimming is by means of its pleopods, that of a *Crangon* or *Palæmon*.

In this stage the antennæ are short, and their length seems to vary a little in different individuals. Certain megalopa have antennæ which reach just in front of the tip of the chela when it is stretched straight out alongside the rostrum. Others have much shorter antennæ. The setose exopodites are only present in some of the examples of this stage.

The megalops is the homologue of the sixth stage of *Crangon vulgaris*, in that it has practically the adult characters, save for its very short antennæ. It crawls about on the bottom of the box, and resists any wave

motion of the water which would tend to float it away. It clings with all its pereopods to the silk cloth of the bottom until the wave motion ceases, when it starts crawling again. Immediately the box is agitated, again it halts and holds on.

In its ability to notice particles of food, the megalops appears to be as keen-sighted as the zoëa. Mead contrasts the habits of the zoëa and megalops.

The next, that is the first young stage, swims about after copepods, and is to be seen swimming forward with the two chelæ extended together straight in front. The antennæ of this stage are longer than in the megalops, and the following stage has still longer antennæ.

The stages subsequent to the megalops are even more difficult to dislodge from the corner of the box. They cling tenaciously to the bottom (silk gauze) until the water is withdrawn and they are left stranded. Then they loose their hold to follow up the water. This fact probably accounts for these stages never being met with in the tow-net. They are really bottom forms, and in shallow water would require to be able to stick well to stones or in crevices to prevent their being washed away.

A young form will sometimes swim round the edge of the box with the off antenna stretched out in front and the near one thrown back along the body.

Appellôf remarks regarding the first young stage that they hide in dark corners or under stones. They are then very stationary. He draws attention to the great caution shown by the young lobster, and considers that, in consequence of that trait, a relatively large percentage of them should survive.

On the approach of winter the little lobsters in the Laboratory became very sluggish. In November and December 1902 they were rarely seen, except when the boxes were lifted. They stuck to the darkest corner of the box, and did not move about so much as they did earlier in the year. During these months there were hardly any copepods in the water supply, and this may have had something to do with their sluggishness. The increasing cold was, however, doubtless the main predisposing cause of their inactivity.

One of the most noticeable features that accompanies the transition from the zoëa to the megalops is the sudden change in the character of the animal. The zoëa swims about in an aimless way, except for the moments when it pursues a copepod. It paddles persistently, and when it strikes against the side of the box it jerks away quickly. It is not disturbed by noticing anything; all it appears to see is the little particles of food. It evidently sees short distances only. The main point is its indifference to possible danger; it does not attempt in any way to conceal itself. In the zoëa stage the lobster had no fear or premonition; in the megalops, it assumes with the adult garb the haunting fear of attack, which leads it to hide itself in some protecting crevice. It comes to rest in the darkest corner of the box, and while swimming about is always on the alert for a possible foe. For everything, food and protection, it has to be completely self-dependent. The desire to hide appeared with the necessity. The bottom life is, without doubt, a dangerous one, possibly more so than the pelagic existence it had just passed through. Its eye still enables it to pick up copepods; it is large, as in all the early stages of decopod crustacea. It no longer swims aimlessly about, but simply occasionally on a foraging expedition.

All the larvæ ate crab's liver, and hunt it by sight as it falls. And in the case of the megalops, when a little crabs' liver was introduced into the box, the lobster became very excited and rushed hither and thither,

following the scent dispersed by the current of water flowing through the box.

One little lobster took up its abode for a day or two in a *Purpura* shell which lay on the sand that covered the bottom of the aquarium, but when it attracted attention, it had excavated in the sand a hole below the shell, and in it it lay. The hole was deep to the front, and was a neat fit. The lobster pushed out a quantity of sand, two armsfull, in front of it, and removed larger grains of sand and a little piece of debris with its maxillipedes. When returning from a promenade round its prison it carefully tested its lair before it backed into it. It was alone in the aquarium. Now this lobster did not imitate an adult or any other young lobster in taking up its abode in the shell, or in digging a cave in the sand. When food was tumbled in it seemed to resent its approach. It appeared to be attracted by the scent at first, and then it put some fresh mussel that tumbled into its cavity out of the hole, while some mussel that was apparently old was left in. It was noticed that the mussel stuck to the pereopods.

Another little lobster, in its wandering about among the sand and mud, got its pereopods and maxillipedes covered with fine debris which, no doubt, consisted, in considerable part, of diatoms. It was observed to pick off the debris and put it into its mouth. Sometimes the mud in the aquarium was all punctuated as if it had been probed all over with the legs of the lobster.

THE LARVAL STAGES.

In the lobster the zoëa is a much more specialised organism than in certain of the other decapod crustacea, *e.g.* *Crangon* and *Carcinus*. One important respect in which the former differs from the two latter is in the possession of functional gills. The presence of the gills determines the form of the appendages concerned in the respiratory function, viz. the second maxilla, and the maxillipedes which are employed in securing a circulation of water through the branchial chamber. The gills and their arrangement being very nearly similar to the condition in the adult, it follows that the function of the appendages is that which they perform in the adult, and their form is therefore practically that of the adult. In *Crangon* and *Carcinus* the maxillipedes have no respiratory function to perform in the zoëa; they and the second maxilla are in form quite dissimilar from the adult condition. The adult form of these appendages are similar but not identical in the lobster and *Crangon*.

The stages which will now be described have not been determined by following a lobster in its successive moults. They have been discriminated from the general collection of larvæ which were developing in the hatchery. In the case of the higher stages, *e.g.* last zoëa stage, megalops, first and second young stages, the casts connecting adjacent stages were observed.

During the research it was found necessary to redissect this form which has already been treated by Sars and others, while the American species has been worked out by Smith and Herrick in elaborate detail, and profusion of drawings.

The drawing in the present case represents the condition found in the appendage examined. The opportunity did not occur to dissect several zoëæ of the same stage with a view to determine the variation in each limb, and from that to fix the normal condition. When a comparison has been instituted between the limbs of different zoëæ, variation in the hair arrangement, and in the nature of the hairs themselves, has been noted.

In the sketch the exact number and arrangement of the hairs, &c., has been attempted, except in the case of figs. 7 and 16, and the drawings of the protopodite joints. The exact number of setæ is not introduced on the exopodites, pleopods, uropods, or, in certain cases, on the telson. In the drawings of the complete larva the pereopods are represented semi-diagrammatically.

THE APPENDAGES OF THE FIRST ZOËA.

The appendages present in the first zoëa stage are—(1) the Eyes; (2) Antennules; (3) Antennæ; (4) Mandibles; (5) First Maxillæ; (6) Second Maxillæ; (7) First Maxillipedes; (8) Second Maxillipedes; (9) Third Maxillipedes; (10) First Pereiopods; (11) Second Pereiopods; (12) Third Pereiopods; (13) Fourth Pereiopods; (14) Fifth Pereiopods. It possesses all the cephalic and thoracic appendages which the adult has. The telson is triangular. The pleopods and uropods are not yet developed.

A detailed description is not necessary; in addition to the drawing of each appendage, short notes will be merely added here.

EYE, *o.*, fig. 4, pl. i.

The eye is large, and has a very short stalk.

ANTENNULE, *a.*, fig. 2, *ib.*

The antennule is crowned with three æsthetascs, one of which is specially large, and two hairs. A minute hair was found at the base of the æsthetascs on the antennule of one side, but not on that of the other side. A little short of the end of the antennule there is a little tubercle surmounted by a short plumose hair. In Sars' drawing of the appendage the plumose hair is shown larger than in the form here described. Herrick's drawing of the antennule of the first stage of the American lobster shows a more differentiated appendage.

ANTENNA, *A.*, figs. 1 and 24, *ib.*

The endopodite or flagellum (fig. 24) is two-jointed. It bears on its extremity four plumose setæ. The antenna represented by Herrick has a segmented or annulated endopodite.

The scale of one side had 23 setæ; that of the other side had 25 setæ.

MANDIBLE, *Mn.*, figs. 5, 6 and 18, *ib.*

The apparent joint in the mandible (fig. 5) above the origin of the palp seems to be simply the edge of its jointing with the cephalon.

The two hairs on the palp (fig. 18) have their distal halves finely serrated.

An enlarged drawing of the cutting edge of the mandible is shown in fig. 6.

FIRST MAXILLA, *1m.*, fig. 27, *ib.*

On the lower lobe the group of four hairs which have been, for convenience, represented as pointed downwards, should be directed upwards.

SECOND MAXILLA, 2*m.*, fig. 9, *ib.*

The second maxilla is really a maxillipede; it forms with the maxillipedes a series of appendages which, in addition to subserving a feeding function, also share the mechanical part of the respiratory process. This is performed by means of the epipodites.

The epipodite of the second maxilla is the lower half of the scaphognathite, while the exopodite is represented by the upper half.

The division of the second maxilla into joints is difficult to follow. My interpretation of the arrangement is as follows: (1) a basal joint; (2) immediately above that a bi-lobed joint; (1) and (2) form the protopodite. Above No. 2 there is a three-lobed joint, the endopodite. The scaphognathite, which seems to be divided at its middle into two joints, represents in its top half the exopodite, and in its lower half the epipodite.

There are 81 plumose setæ on the margin of the scaphognathite, and four small hairs on the surface.

On the elongated top lobe of the endopodite the long hairs are sparsely plumose; they are stiff spine-like hairs, with short, stiff cilia given off in pairs. The tips of the hairs are curved.

There are 20 hairs on the second lobe; they also have curved extremities. They are, with three sparsely ciliated exceptions, plain hairs; one hair only was distinctly serrated on its distal half.

The third lobe bears 13 hairs on the margin, and two on the under-surface. They resemble those on the second lobe; only a few are ciliated.

On the fourth lobe there are stout hairs sparsely furnished with stiff cilia on their proximal halves, and serrations on their distal halves.

The fifth lobe has long, stiff plumose bristles.

FIRST MAXILLIPEDE, 1*mp.*, figs. 7, 10, and 23, *ib.*

The first maxillipede (fig. 7) has a large first protopodite joint bearing a large epipodite. The upper lobe of the epipodite appears to be segmented off. The second protopodite joint is a flattened lobe bearing a large number of serrated spines on its margin (fig. 23).

The endopodite is two-jointed (fig. 10), and bears several long sparsely plumose bristles.

SECOND MAXILLIPEDE, 2*mp.*, figs. 29, 14, and 19.

From the first protopodite joint there arises two processes, united at their bases, one of which is a rudimentary gill, while the other is an epipodite (fig. 14). Both are hollow. An interesting condition was noticed in the gill, which may or may not be constant. The subject was not investigated. In the side of the gill there was a pore opening into a central cavity (fig. 14). The gill is not segmented. Between the wall of this central cavity and the outer wall there is a space which communicates with canals in the protopodite. The hollow of the epipodite communicates with a canal in the protopodite. In the drawing the canals are dotted; the basement tissue is striated.

The exopodite and endopodite arise from the second protopodite joint (figs. 29 and 19).

The exopodite, which is furnished with two terminal hairs and a little terminal protuberance, has a long basal joint and a long flagellum incompletely divided by two septa.

The endopodite consisted of four joints ; that is one less than what it has later, and which the first stage specimen dissected by Herrick had. The first long joint in the present case showed a trace of division into two.

The armature of the endopodite consists of serrated thorns resembling those on the same appendage in the VI. and VII. stages of *Crangon*. So far as was made out, they were, without exception, serrated. The serrations are minute, except in the large thorns. In fig. 29 the teeth are exaggerated.

THIRD MAXILLIPEDE, *3mp.*, figs. 8 and 16.

Two gills and an epipodite are attached to the first joint of the protopodite. One of the gills is a podobranch, the other an arthrobranch (fig. 16). On the edge of the epipodite there are three hooks, of which the two larger are anterior. There is a second arthrobranch.

The exopodite had two terminal setæ and ten on each side. The annulations on the exopodite appear to be complete joints.

The endopodite has five joints. The spines are, almost without exception, serrated. Those on the under-surface (of the sketch) have two rows at least of large teeth ; the other spines have small serrations, of which there are two rows at least. The long terminal spine has very few serrations.

PEREIOPODS.

The pereiopods drawn are all of the right side.

The pereipod consists of seven joints, viz. (1) first protopodite joint—Coxopodite ; (2) second protopodite joint—Basipodite ; endopodite joints, viz. (3) Ischiopodite ; (4) Meropodite ; (5) Carpopodite ; (6) Propodite ; (7) Dactylopodite.

The setose exopodite arises from the basipodite.

FIRST PEREIOPOD, *1per.*, figs. 11, 20, and 28.

There are four gills connected with this limb—a podobranch, two arthrobranches, one pleurobranch, and an epipodite.

The endopodite has five joints, but the distal limit of the ischiopodite is shown by a line merely across the limb ; it is not a movable junction.

On the propodite the spines, almost without exception, are serrated ; those on the same side as the dactylopodite have prominent serrations, those on the opposite side very small serrations.

There were 22 or 24 setæ on the exopodite.

SECOND PEREIOPOD, *2per.*, figs. 22, 21, 12, and 15.

As in the preceding, appendage the first joint on the endopodite is marked by a line crossing what would otherwise be a first long joint of this branch ; giving five joints in all. The hand has serrated spines ; those on one side having larger serrations than those of the other side. There are three teeth on the inner edge of the dactylopodite.

There were 24 setæ on the exopodite.

Four gills and an epipodite are connected with this limb.

THIRD PEREIOPOD, *3per.*, figs. 13, 17, 25, and 26.

The endopodite is incompletely segmented ; it has four joints.

The spines on the claw of the propodite have large serrations.

The exopodite had 24 (26) setæ.

Attached to the appendage are four gills and an epipodite.

FOURTH PEREIOPOD, *5per.*, figs. 42, 52, and 45.

The endopodite shows five joints. On the propodite the spines have very large serrations on their distal halves, and smaller teeth on their proximal halves. On the other side the spines have small serrations. There are two kinds of serration on the long spine of the dactylopodite. At the base of this spine there is a tooth on the dactylopodite.

The exopodite had 24 (26) setæ.

Four gills and one epipodite are connected with this limb.

FIFTH PEREIOPOD, *5per.*, figs. 42, 52, and 45.

On the endopodite there is a little tooth at the base of the terminal spine.

The exopodite had 22 setæ.

One gill, a pleurobranch, is connected with the fifth pereiopod.

BRANCHIÆ.

The number and the arrangement of the gills of the first stage zoëa are similar to the condition in the adult. Two of the gills, however, are here rudimentary. In fig. 49, pl. ii., the branchial cavity is shown. The gills are represented in the positions they occupy, but are shown much more slender than they actually would appear. They are packed close together. The division of the gills into podobranchiæ, arthrobranchiæ, and pleurobranchiæ is clearly shown in the case of the majority of the gills, but some there are which, from their position, might be regarded as pleurobranchs. In the adult, however, they are arthrobranchs, and very probably are arthrobranchs in the larva. They are the gills on the top row of the arthrobranchs in the following scheme. The Table exhibits the arrangement of the gills in the first zoëa stage (*vide* fig. 49). The gills are arranged in the branchial chamber in four rows. The highest row consists of four pleurobranchs belonging to the second to fourth pereiopods. The next row consists of five arthrobranchs which are connected with the third maxillipede and first four pereiopods. The third row comprises another set of five arthrobranchs attached to the same appendages. The fourth row includes six podobranchs, borne by the second and third maxillipedes and the first four pereiopods. The first and last of the series are rudimentary gills. Each of the above-mentioned appendages, with the exception of the fifth pereiopod, has an epipodite. On the coxopodite of the last pereiopod there is a small process which may represent the epipodite.

Herrick says that in the American lobster there is no rudimentary gill attached to the second maxillipede.

In Fig. 49 the following letters are used:—*pl.-br.*, Pleurobranch; *ar.-br.*, Arthrobranch; *pd.-br.*, Podobranch.

Branchiae of First Zoëa Stage.

1st Row -	Pl.	Pl.	Pl.	Pl.	..	..	..
2nd „ -	..	Ar.	Ar.	Ar.	Ar.	Ar.*	..
3rd „ -	..	Ar.	Ar.	Ar.	Ar.	Ar.	..
4th „ -	..	Pd.	Pd.	Pd.	Pd.	Pd.	Pd.
„ „ -	..	Ep.	Ep.	Ep.	Ep.	Ep.	Ep.
Appendage.	5 per.	4 per.	3 per.	2 per.	1 per.	3 mp.	2 mp.

ABDOMEN.

On the dorsum of the abdomen there are three single spines and a pair of hooks. The spines arise from the third, fourth, and fifth abdominal segments, and the pair of hooks are situated on the hind border of the sixth segment. In the larva of the American lobster there is a small hook on the second segment also.

There are four pairs of rudiments of pleopods; they are paired swellings projecting below the ventral line. Each is widely separated from the other pleopod of the pair. The integument is apparently perforated for the outward growth of the appendage, in a manner similar to the bud of a new limb. Inside, a fold can be seen.

In each segment there is a pair of nerve ganglia. In the examination of the first stage of *Carcinus* the ganglia are noticed, but were not recognised.† There is a little tooth on the side near the anus. On the hind border of the telson there are 16 (17) little setæ on either side of the median spine. In the dorsal view of the abdomen and telson the exact number of setæ is not shown on the hind border of the telson.

FOOD OF THE ZOËA.

he stomach of one zoea contained the integument of a copepod.

SUBSEQUENT STAGES.

As mentioned above, there has been some difference in opinion regarding the number of stages into which the zoëa period is normally divided. In the European lobster Sars distinguished three stages; Saville Kent made out four distinct stages; Chadwick has described three stages. Herrick, for the American lobster, discriminated three zoëa stages only.

The difficulty arises from the fact that during the zoëa period the different developing appendages do not proceed *pari passu*; and while, no doubt, there is normally a correlation between the organs which results in a certain stage of development in the one being usually associated with another certain stage in the second appendage, still the variation

*The arthrobranch in the second row, connected with the third maxillipede, is hidden by the adjacent arthrobranch of the first pereopod.

† *Vide* Williamson. The Larval and Early Young Stages of the Shore-Crab (*Carcinus maenas*), p. 157.

is comparatively very large. How is the number of zoëa stages to be fixed? The most direct method is to watch a zoëa in its development from hatching till it reaches the megalops stage, when it changes its mode of life and assumes the form of the adult. In the zoëa period every moult ushers in a new stage. As will be shown later, however, the megalops is not a fixed condition; a large amount of variation occurs in its structure. The development of a single example would not be sufficient; a number would be necessary. In the zoëæ of *Crangon* and *Carcinus* variation was noticed, especially in the size of larvæ of the same developmental stage. These zoëæ are of very small size, whereas the lobster larva is large. The variation, then, in the latter is of much greater absolute size. The variation in size and in the development of the appendages together result in a multiplication of forms. Causes which are at present unknown—they may be food, temperature, salinity of the sea-water, &c.—stimulate development in certain or all the characters in some larvæ, while apparently similar conditions of environment result in delayed development in other specimens. The method adopted in the present case has been to group the zoëæ into as many groups as they naturally fall into. Of these there are three. But the extent of variation is sufficiently large to bring into prominence three other distinct forms. In the first group of zoëæ there are two dimorphic forms, and it might be inferred from that fact that we had simply to deal with two parallel series, but that does not appear to be the case. One case at least occurred where a larva belonging to one series passed by a moult apparently into the other series.

The zoëa stages are very readily distinguished by the stage of development of the pleopods. During the zoea period the pleopods develop and become functional for the first time in the megalops. This occurred, without observed exception, in the case of *Crangon* and *Carcinus*.

In *Homarus* the first zoea has the rudiments of the pleopods; they do not project from the abdomen; they are merely paired swellings on the posterior part of the under-surface of the abdominal segment. In Stage II. the pleopods project as unjointed bifid processes. In Stage III. they are large two-bladed appendages.

In the first zoëa the cornea of the eye is attached to the carapace; the eye is sessile. In the second and third stages it is quite free from the carapace; the eye is distinctly stalked.

The telson in the first zoëa is triangular, its hind margin fringed with plumose setæ. No uropods are present. The uropods appear in Stage III.

In each stage there is a marked variation in size, and the large individuals usually show considerable divergence in structure from the small specimens of the same stage, in respect to the developing appendages.

In Stage I. one or two large specimens, Ia. (fig. 67), but not all, showed a telson differently shaped from that of the smaller. But between these two, some larvæ showed intermediate forms of the telson. Then a difference in the size of the ventral swellings (pleopods) on the abdomen was noticed, but the more prominent swellings were not confined to zoëæ having the second form of telson.

In Stage II. (fig. 68) the outstanding difference between the larvæ was that of size; a dimorphic form was not noticed here.

In Stage III. (fig. 69) difference in the size and structure of the pleopods is common. The dimorphic form of the third zoëa (fig. 71, pl. iv.) is one which, in structure, is intermediate between Stage III. and the megalops.

None of these dimorphic forms have, so far as I am aware, been previously recorded and described. It is possible that their origin may,

in some measure, be due to the environment; the conditions, favourable and unfavourable, of their life in the Laboratory may have resulted in stimulating these irregular forms. The lobsters were under the influence of this environment for a month or so while in the egg, and afterwards during the whole of their free existence. The parent lobsters were from two widely separated localities, viz. the East and West Coasts of Scotland. The young forms were mixed together in the hatchery. The different origins of the parents might be accompanied by variation in development of the larvæ.

It is convenient to discuss the stages in the order of their sequence.

STAGE I.—Saville Kent breaks up this stage into two stages, which he separated by two characters:—

(1) Difference in size.

(2) Difference in the number of dorsal spines on the carapace.

Difference in size is not a character of value; and as regards the second, I have not been able to discover this difference.

A very marked difference was found, however, between certain of the first zoëæ, in the shape of the hind border of the telson. In the majority the hind margin makes with the hooks at the angles of the base a return curve of comparatively small radius (fig. 30). In some of the larger specimens Ia. (fig. 67) the telson is broader, the curve of the hind margin is a much shallower one, the lateral hooks being directed posteriorly instead of inwards (fig. 46). The setæ on the hind border are very short, while in the first described case the setæ were fully half the length of the median spine. Now, in *Crangon vulgaris*,* the second stage differs from the first in having a telson of slightly different shape, accompanied by a greater number of spines on the hind border. There is also a difference in size. This fact would suggest the possibility of the two forms in Stage I. being independent stages, but the length of the setæ was found to be variable, and cases occurred where it was impossible to say, from the length of the setæ, to which form the individual belonged. I have come to the conclusion that there is not sufficient differentiation to warrant its elevation to a separate stage.

The second zoea (fig. 68, pl. iv.) is the first stage in which the pleopods project. They are unjointed bifid processes. They issue, by foramina in the integument, from the posterior part of the under-surface of the 2nd, 3rd, 4th, and 5th abdominal joints. The telson (fig. 48, pl. ii.) has 16 little setæ on either side of the median spine. On the outside of the setæ there is a little spine at the base of the lateral hook. The uropods are not yet free, but may be traced through the integument of the telson. Two zoea of this stage measured 10 and 12mm. respectively—a very conspicuous difference in bulk.

The third zoea shows a certain amount of variation, and between the third zoea and the megalops, and in the megalops, variation is well marked. The dimorphism was noticed in respect to two characters especially, viz. those which are in process of development in the zoea period, e.g. the antennæ and the pleopods.

The third zoea (fig. 69, pl. iv.) is characterised by the possession of uropods. The telson, which is square, is toothed along its hind border (fig. 35, pl. ii.). There were 18 teeth on either side of the median spine in the specimen examined. On one side there was a little setose hair. Two or three short plain hairs were found on the dorsal surface of the margin. The pleopods (fig. 37) are larger; each consists of a thick stem, bearing two paddle-shaped processes. They are constricted off from the stem, but not by movable joints. The paddles are set across the abdomen,

* Vide Williamson.

and are fringed on both edges of their distal halves with short, stout plain hairs. The exopodite overlaps the endopodite on the anterior side of the latter. In the third pair of pleopods of one larva there were 21 hairs on the exopodite, viz. 13 on the outer side, 2 terminal, and 6 on the inner side, i.e. next the endopodite. The endopodite was somewhat smaller than the exopodite, and bore 19 hairs, viz. 3 terminal and 8 on each side. The endopodite extends as a continuation of the stem of the appendage. There is a variation in this stage which is common; it is the case wherein the pleopod is furnished with rather longer fringing hairs, a proportion, larger or smaller, of which are sparsely plumose. The pleopods apparently function to a slight extent in this stage.

The two forms observed of the third stage then are:—III*a*, zoëæ having pleopods fringed with *short plain* hairs; III*b*, zoëæ having pleopods fringed with *rather longer* hairs, which are in part *sparsely plumose* (fig. 36, pl. ii.). It is possible that III*b* is the more common. This was the structure of the pleopod in the III. zoea stage described by Smith.

The most striking secondary form is one which partakes of the characters of both zoëa and megalops. It will probably be more convenient, then, to define the normal or average megalops before proceeding to discuss the intermediate variation.

The zoëa has certain prominent characters; these are the dorsal hooks on the abdomen, the purely maxillipede form of the pereiopods, the swimming exopodites of the thoracic appendages, and the stumpy antennæ, which do not function as feelers. The pleopods in the zoëa are not fringed with long plumose setæ.

The megalops stage is marked by the antennæ being long, minutely jointed, and used as feelers. The pereiopods function for walking; the exopodites are greatly reduced. The pleopods are furnished with long, densely plumose setæ, and have become powerful swimming organs. The dorsal hooks on the abdomen are absent.

The intermediate stage, which is, for convenience, labelled thus "IV." in the plates, was quite common among the larvæ that were reared. Fig. 71, pl. iv., represents the most common condition of this form; for it also varies. The antennule and the antenna are still not fully developed; the former is single, and bears at its extremity a bunch of hairs. The antenna is longer than it is in Stage III.; it shows some segmentation, and coming joints are indicated externally by the presence of little hairs; it is not a functional feeler. In other respects this form is a zoëa. The spine and hook armature of the abdomen is that of the zoëa. The pereiopods and their exopodites are in the zoëa condition. Drawings of the first pereiopod are given in figs. 43, 44, and 38, pl. ii. The part of the second protopodite joint which bears the exopodite is now segmented. The epipodite is also segmented off from the first protopodite joint (figs. 44 and 38). The protopodite of the second pereiopod is represented in fig. 39, pl. ii. The endopodite has five joints—a chelate tip.

It resembles a megalops in its pleopods, telson, and the hand of the first pereiopod. The pleopods are large, and fringed with long plumose setæ. On the third pleopod (fig. 51, pl. ii.) there are on the exopodite 33 setæ, and on the endopodite 30 setæ. The exopodite overlaps the endopodite on the anterior surface. The hand of the first pereiopod was long, resembling that of a megalops rather than that of the zoëa (fig. 43, pl. ii.).

The Stage "IV." varies to the extent of having its pleopods furnished with comparatively short hairs, some of which at least are sparsely plumose. This is the condition found in the modification of the third stage zoëa, labelled III*b*. The largest specimens are usually furnished

with the pleopods of the megalops. The telson of the "IV." stage, which was drawn, had no median spine on the hind border; in this stage a median spine is usually present.

Stage "IV." attracts attention from the fact that in general shape and large size it resembles a megalops. The use of the pleopods for swimming give it the characteristic megalops appearance. It swims with the chelæ stretched straight out in front of it. It may be regarded either as a backward megalops, or as a precociously developed zoëa. From the point of view of the former, the antennæ, which are so prominently employed by the megalops, have developed more slowly than the pleopods. We have, in fact, a megalops which has carried over certain zoëa characters, viz. antennules, antennæ, the purely maxilliped form of the pereopods, and the abdominal hooks. There are other cases in which minor zoëa characters are carried over and exhibited in the megalops; they will be referred to later. If the second view is adopted, we are led to the interesting conclusion that an organ may by precocious development become functional in a stage which is normally without it.

Might not an unusually rapid growth of the zoëa in size necessitate the earlier provision of swimming organs to assist the exopodites which were sufficient in the smaller stages? Or might a lower salinity react by stimulating the development of greater swimming power? The zoëa has attained to the body of a megalops, and the result is the provision of the means of moving it about.

Boas describes considerable difference in structure between the larvæ and adults of the fresh-water and sea-water forms of *Palaemonetes varians*. The larva of the former is larger than that of the latter.

The megalops stage is illustrated by several figures. Fig. 72, pl. iv., shows the lobster in this stage. The pereopods are represented by figs. 60, 61, 62, and 58, pl. iii., while the abdomen and telson are shown in figs. 57 and 63, pl. iii.

The exopodites of the pereopods are present, and setose, though very much reduced; but variations in the exopodites are common. In the stage following the megalops, viz. the first young stage, the exopodites are reduced to little processes (*vide* figs. 59, 65, 70, pl. iv.).

While dissecting a megalops the first pereopods broke off at the junction between the basipodite and the ischiopodite. These joints, so far as could be made out, were fixed, as they are in the adult. This is the fracture plane of Fredericq. The broken limb showed a clean but not very regular break (fig. 58, pl. iii.). The muscles in the ischiopodite run right down and terminate at the proximal end of that segment. The muscles of the exopodite may have something to do in effecting the fracture.

The pleopods are similar to those of Stage "IV." (fig. 51, pl. ii.). The setæ have long, stiff cila, and resemble generally the setæ on the pleopod of the megalops of *Crangon vulgaris*.

The telson of the megalops had a median spine on the hind border. This spine is usually absent; it is a zoëa character.

The chela resembles that of the first young stage (fig. 65), but the tubercles on the meropodite are a little less prominent.

The first young stage resembles much the megalops (*vide* fig. 70, pl. iv.), but is usually larger. The exopodites of the thoracic limbs are small processes, no longer setose. The antennæ are longer than in the megalops. The pleopods are similar to those of the megalops. The rostrum is bifurcate. On the whole, the lobster in the first young stage resembles much in its habits the lobster in the megalops stage. It does not appear to swim quite so much.

The first pereopod of this stage is figured in figs. 65 and 59, pl. iii

The little hairs on the propodite and dactylopodite are probably sensory. Fig. 64, *ib.*, gives a dorsal view of the telson.

VARIATION OF THE MEGALOPS.

A typical megalops may be described as follows. It walks about by means of the pereopods, which are now of the adult form, and it swims by means of its large pleopods. The exopodites of the thoracic appendages are present, but in varied structure. They may be setose, or much reduced, and without setæ. The antennæ now project as far in front as the chelæ can reach, and are used, as in the adult, as feelers. The rostrum is bifurcate at the tip. The eyes, like those of the zoëa, are very large.

The megalops varies in several ways—the following were specially noted:—

(1) It as often as not has one or more of the dorsal abdominal hooks of the zoëa persisting.

(2) It may have the median spine on the hind border of the telson—a zoëa character.

(3) The exopodites may vary very much. Some or all of them may be setose, or they may be reduced to little processes, as in the first young stage. The exopodite of the first pereopod does not usually have any setæ.

The following Table gives an analysis of 12 megalopa with respect to three characters. The sign + signifies the presence, and – the absence, of the character; if no sign is entered the character had not been noted.

	Dorsal Hooks on Abdomen.	Median Spine on Telson.	Exopodites— some Setose.	Exopodites reduced to small pro- cesses.
4 Megalopa,	+		+	
1 Megalops,	+			+
5 Megalopa,	–		+	
1 Megalops,			+	
1 Megalops,		+		

FORMS RESULTING FROM THE CASTING OF III. AND “IV.” ZOËÆ.

Particulars were kept of various casts of the III. zoëa and of the “IV.” stage. The resulting forms were observed, and are entered in the following Table:—

[TABLE.

Stage.	Cast into	Special Characters of Resulting Form.
IIIa.	"IV."	Pleopods and Telson of Megalops.
IIIa.	"IV."	
IIIa.	Megalops.	Short Antennæ.
IIIb.	"IV."	Pleopods of Megalops.
IIIb.	Megalops.	
IIIb.	"	
IIIb.	"	
IIIb.	"	
"IV."	"	In some respects, <i>e.g.</i> Exopodites of Pereiopods, resembled First Young Stage.
"IV."	"	" " "

GROWTH OF THE YOUNG LOBSTER.

The larval stages of the American lobster have been fully treated by Herrick, who followed its life-history from the time of hatching to the tenth stage, when the animal is over one inch long and about three months old. He says that the young lobster ceases to swim in the sixth stage.

In the Laboratory here the young lobsters have been kept for various intervals up to ten months. Rearing experiments were carried on in the summer of 1902 and the summer of 1904. In the case of the lobsters which were kept for several months, it was not possible to tell in what month they were hatched, but as the greatest number of the fry hatched out in August, the middle of that month has been taken as the date from which to calculate the age of the young lobsters. The growth in the cases here cited is possibly abnormally slow.

A. 1902 Brood—Hatched in August 1902.

1. September 28-30th 1902.—Megalopa issued from three specimens of the large "IV" zoëa.
- „ October 30th.—One megalops cast.
- „ November 6th 1902.—Another megalops cast.
2. October 1st.—A zoëa cast into a zoëa of "IV" stage.
- „ November 7th.—The "IV" zoëa was partly cast to megalops.
- „ December 5th.—The megalops was dead; 1.6cm.
3. October 2nd.—A zoëa cast; a megalops issued.
4. November 7th.—A megalops cast.
5. November 21st.—A first young stage lobster cast.
- „ December 4th.—The soft lobster, second young stage, was found dead; 1.4cm.
6. December 13th.—A lobster of the second young stage died; 1.7cm.
7. January 15th, 1903.—A first young stage lobster died; 1.7cm.
8. „ 17th.—A first young stage lobster died; 1.8cm.
9. „ 27th.—A second young stage lobster died; 1.7cm.
10. May 29th.—A second young stage lobster cast.
- „ June 11th.—The soft lobster, third young stage, died 1.8cm
11. May 31st.—A second young stage lobster cast.
- „ „.—The soft lobster, third young stage, died; 2.2cm.

B. 1904 Brood—Hatched in August 1904.

12. October 27th 1904.—Young lobster, first young stage, cast.
,, November 3rd.—The soft lobster, second young stage, died ; 1·cm.
13. 31st October.—Young lobster cast.
,, November 3rd.—Soft lobster died ; 2·5cm.
14. June 4th 1905.—One young lobster, the sole remaining, measuring 1·9cm, cast.
,, ,, 14th.—The young lobster died ; 2·1cm.
Casting of zoëæ occurred as late as October and November and of megalops and later stages in October, November, May, and June.

LENGTH OF DIFFERENT STAGES.

The last zoëa stage lasted, in the case of No. 2, from October 1st to November 7th, a period of five weeks.

The megalops stage lasted, in the case of two examples in No. 1, from September 30th to October 30th and November 6th, i.e. four and five weeks respectively.

Appellôf records that two lobsters in the same jar differed from one another by a month in arriving at the sixth stage. Casting took place also in winter.

Sizes of the young lobsters which died, and their approximate ages (from hatching) at death :—

Stage.*	Age.	Length in Cms.	Number in preceding List.
M	2 months	1·6 : 1·7	..
M	2½ "	1·6	2
+2	2½ "	1·7	12
..	2½ "	2·5	13
+2	3½ "	1·4	5
+2	4 "	1·7	6
+1	5 "	1·7	7
+1	5 "	1·8	8
+2	5 "	1·7	9
+3	9 "	2·2	11
..	10 "	2·1	14
+3	10 "	1·8	10

* The following contractions are used in this column:—"M," Megalops ; "+1," first young stage, i.e. stage immediately following Megalops ; "+2," second young stage, &c.

Additional measurements of lobsters of different stages:—

Date.	Stage.	Measurements. <i>Mm.</i>
Sept. and Oct. 1902.	“ IV ” Zoëa.	1·5 : 1·5 : 1·6 : 1·6.
„	M.	1·5 : 1·5 : 1·5 : 1·5 : 1·6 : 1·6.
Sept. 1902.	+ 1	1·55 : 1·55 : 1·6 : 1·65 : 1·7 : 1·7.

DEATH OF THE YOUNG LOBSTERS, FIRST YOUNG STAGE AND LATER.

The majority of the young lobsters reared at the Laboratory have died shortly after casting. As a rule, the death took place gradually, as if a disease had seized them immediately on casting. The lobster became at once sluggish, moved about with difficulty, and simply ebbed away.

October 23rd (No. 3).—One of the young lobsters cast, but became weak immediately after, and was hardly able to move a limb. It was removed to a larger vessel with a good supply of water, and it seemed to be reviving on the 28th. On *October 31st* it was livelier; it could move its pleopods, but seemed to be paralysed in the thorax; a faint movement of the antennules was noticed. It had a large swelling on its left side at the hind part of the carapace. It was dead on *November 3rd*.

On October 31st (No. 5) a lobster that had not cast recently was seen to be almost dead; there was just a little movement detected in the last pleopod. On *November 3rd* it was dead and covered with a fungoid growth.

On November 3rd (No. 6) a lobster which was half-cast was found as if dead. No movement was noticed. The lobster was torn asunder, and it was then seen that life still remained, as vermiform movements of the organs were detected. A puff of white fluid material was squeezed from the anterior half of the body, and examined by means of the microscope. It was seen to consist of great numbers of infusors of various kinds, the majority being very small and roundish in shape; others were long, pear-shaped. Some were progressing with an eel-like motion. Sporospheres consisting of a mass of minute infusors were made out. The water in which the lobster was had no infusors in it when a drop was examined.

The death of the young lobsters is, without doubt, due to the rapid development in them of these infusor parasites. It is possible that during the casting process the infusors may gain admittance to the body, and their rapid multiplication there results in the death of the host in a few days.

One lobster, the largest reared, measuring 1 inch (2·5cm.) in length, reached that size by a cast on *October 31st* 1904. On *November 3rd* it appeared to be dead. On examination a little movement was detected in its limbs. It was removed to a large jar, but did not recover.

BERRIED LOBSTERS OF SUMMER 1902.

The parent lobsters from which the supply of larvæ was obtained in 1902 were kept alive in the Laboratory after the hatching finished. Two survived till the spring of 1905. The history of these and of other lobsters which were kept in confinement will now be detailed.

One lobster was found clean hatched on August 2nd 1902, and by September 10th all but one had hatched out their eggs. The exception was a lobster upon which a quantity of dead eggs remained attached to the swimmerets. On September 22nd one lobster cast its shell; when examined on October 14th the shell of this individual was not hardening quickly. None of the others cast, and none spawned. If spawning actually occurred none of the eggs became attached to the adult. The lobsters were ten in number on January 16th 1903. None, so far as could be made out, had spawned; one had still a quantity of empty egg-capsules, visible to the naked eye, attached to the swimmerets. The soft lobster died on June 6th 1903.

On July 6th 1903 eight of the 1902 hatchers survived. During that month six cast their shells; one cast in August, and the eighth died in July. Of the six which cast in July, three died in the process of casting.

The four soft lobsters had not spawned in October, in which month a male lobster was introduced into the tank with them. On January 13th, 1904 the male lobster was still with them; none had become berried.

One of the females was found cast on July 19th 1904, and it died the following day. A second cast on July 29th. The third was found dead on August 30th 1904. There were left at that date two lobsters; one of these had cast its shell in 1903, and also in 1904; the other had cast in 1903. The male lobster remained with the latter. Both females were still unberried on 21st October. Neither had spawned by January 12th 1905. The lobster that cast in 1904 was found dead on February 16th 1905, and the remaining specimen had died by April 6th 1905.

During the two years and nine months the majority cast their shells, but none became berried.

A FEMALE THAT SPAWNED.

A marketable* female lobster arrived from Dunbar in December 1902. It had a clean shell, and did not appear to have been berried. It cast its shell on September 2nd 1903. When examined on the 12th October following it measured 10½ inches in length. It was not berried on January 13th 1904, but on July 14th it was found to have a small quantity of eggs attached to the swimmerets. The eggs were early, just spawned. No male lobster was present when the eggs were spawned. These appeared to be healthy, dark green in colour, with a clear dotted area to one side. The lobster had lost all its eggs but two by October 21st 1904, and when examined on November 19th of the same year it was clean. On the subsequent examinations, viz. January 12th, May 6th, and June 19th 1905, the lobster was still clean. It moulted on July 2nd, 1905, and was killed then. This cast has not been entered in the table on p. 90.

BERRIED LOBSTERS OF 1903.

Some berried lobsters, eight in number, were obtained from Dunbar in September 1903. Two had well-developed eggs, and the eggs hatched soon after arrival. By September 24th two more had hatched their eggs; a few eggs remained attached to one lobster. The four others had black

* A lobster is marketable when it is eight inches, and over in total length of body.

eggs, which appear to have been freshly extruded. They were not retained at the Laboratory; the clean-hatched lobsters were preserved alive. During the winter that followed none, so far as was noticed, spawned, and on January 23rd 1904, of the three that remained, none was berried. One lobster cast on July 9th 1904. The cast shell was clean; the antennæ which had been most exposed to the light had some algæ growing on them. It died on July 14th. The second lobster cast on July 13th, and the third on July 25th.

By October 21st 1904 only one survived, and it was not berried. It was examined again on November 19th 1904, January 12th 1905, May and June 19th 1905, and on each date found to be unberried.

BERRIED LOBSTERS OF 1904.

A stock of berried lobsters, 20 in number, were obtained from Girvan and Dunbar in June and July 1904. All but five hatched their eggs by the end of August. These were still berried on October 12th 1904. Of the others, one cast in August, one cast in September, four more had cast by October 12th 1904, a seventh cast on October 29th 1904, and the eighth was found cast on November 1st 1904. Of the fifteen which hatched their eggs, eight cast their shells by November 1st. The remainder, seven in number, were examined on December 15th 1904, January 12th 1905, May 8th and June 19th 1905. None had become berried. At the examination in May one had died.

Six of the soft lobsters had died by November 16th 1904; none of them had spawned. On January 12th two were alive, but they had succumbed by May 6th 1905.

When the berried lobsters were examined on October 12th 1904 the external eggs showed, under the microscope, a considerable pink area at one pole, wherein were to be made out the pigmented eyes and the rudiments of the limbs. The great mass of the egg consists of black yolk. The lobsters had probably spawned their eggs just before they were captured in July.

On January 12th 1905 the reddish or amber-coloured area had increased a little; it extended well round the black yolk. The eye of the embryo has a prominent black retina; the limbs are distinct.

When examined on May 6th 1905 the eggs showed a further increase in the red area; it extended almost completely round the yolk, but was still narrow in most of the eggs. At this date four lobsters remained; of these, one had got rid of its eggs. Two were clean on June 19th 1905. The eggs of the two others were far advanced.

PROPORTION OF BERRIED HENS IN THE CATCH OF LOBSTERS.

As to the proportional numbers of berried to unberried females captured by the fishermen, Herrick's observations showed that in April and May the largest percentage of berried females were captured in Wood's Hole Harbour. In these months the berried females formed 40 and 36 per cent. respectively of the total number of female lobsters taken.

Ehrenbaum found that at Heligoland the berried hens were taken in largest numbers in July, August, and September, during which months, in the period covered, the percentages were 35, 46, and 44 respectively of the total females.

Cunningham's statistics of the lobsters caught in the Cornwall district show that in April, May, June, and July the berried females form a considerable proportion of the total catch. In the three years 1895-

1897 the proportion of berried hens during the months March to July, amounted in some cases to 50 per cent. of the females captured. For the four months April to July, at Cadgwith in 1899, out of a total of 443 females, 108 were berried hens.

Meek has published statistics of the catch of lobsters and crabs during the past six years, 1899–1904, both inclusive. The monthly totals at Seahouses and Beadnell are given for each year. The lobsters are classified as hard, small, and berried. The largest number of berried females were, as in Cornwall, captured in April, May, June, and July. For the six years the berried hens made up on the average in these months 28, 34, 32·7, and 22·8 per cent. respectively of the females captured at Seahouses.

THE CASTING OF THE LOBSTER.

The Male Lobster.

A male lobster obtained in October 1903 was kept in a tank along with four soft female lobsters. On April 14th 1904 it was found to have cast, and on July 14th following it was already hard. It was noticed that it was an eager feeder. When examined on November 19th it appeared to be soft to the touch, and on November 21st it had again moulted; that was after an interval of seven months only from the previous cast. It was killed by the female lobster that was with it in the tank. It had bled to death; the injuries were not very extensive. It measured at its death $11\frac{1}{2}$ inches in total length.

Two male lobsters which were kept in confinement by Brook cast twice in each of two successive years. One, measuring $7\frac{1}{4}$ inches in length, cast in (1) May and again in (2) September 1883, and also in (3) May and (4) October 1884. The size after each cast was (1) $7\frac{1}{8}$ inches, (2) $8\frac{1}{8}$ inches, (3) $9\frac{3}{8}$ inches, (4) $9\frac{3}{4}$ inches. The second male lobster measured $6\frac{1}{8}$ inches. It cast in (1) July and (2) December 1883, and in (3) June and (4) November 1884. The size after each cast was (1) $7\frac{3}{8}$ inches, (2) 8 inches, (3) $8\frac{1}{2}$ inches, (4) $9\frac{3}{8}$ inches.

The Casting Periods.

The lobsters which moulted at the Laboratory did so in the following months:—April, July, August, September, October, and November. All these observations refer to adult lobsters 8 inches and over in length, which were nearly all females. Most of the females were lobsters which were berried when they arrived at the Laboratory. In the following Table they are indicated by the letters e.h. (eggs hatched).

The Table which follows shows the date on which the lobster cast, its length before casting, and sex. The interval of time that has elapsed since the eggs were hatched is given in one column, and the interval between two successive casts is shown in the three cases where it occurred.

The numbers indicate separate moults: the same lobster appears twice in three cases.

[TABLE.

No.	Date.	Size before Casting.	Sex.	Interval between Hatching the Eggs and Casting.	Interval from Previous Cast.	Period of Captivity before Casting.	
		Inches.					
1	April 14, 1904.	...	♂	...	...	...
2	July 6, 1903.	12 $\frac{7}{8}$	♀ e.h.	1 YEAR.	...	...
3	" 15, "	12 $\frac{1}{2}$	♀ e.h.	1 "	...	...
4	" 20, "	11	♀ e.h.	1 "	...	...
5	" 21, "	10 $\frac{5}{8}$	♀ e.h.	1 "	...	...
6	" 22, "	...	♀ e.h.	1 "	..	...
7	" 29, "	11	♀ e.h.	1 "	...	...
8	" 1904.	11 $\frac{1}{2}$	♀ e.h.	1 "	...	...
9	" "	11 $\frac{5}{8}$	♀ e.h.	1 "	...	...
10	" "	12	♀ e.h.	1 "	...	...
11	" "	12 $\frac{3}{4}$	♀ e.h.	2 YEARS.	1 YEAR.	...	
12	" "	11	♀ e.h.	2 "	1 "	...	
13	July 28, 1902.*	...	♂	...	...	...
14	August, 1903.	11	♀ e.h.	1 YEAR.	...	...
15	" 1904.	...	♀ e.h.	1 month.	...	...
16	Sept., 1902.	9 $\frac{1}{2}$	♀ e.h.	1 "	...	...
17	" 1904.	...	♀ e.h.	1 "	...	...
18	" "	...	♀ e.h.	1 "	...	...
19	" 2, 1903.	11	♀ e.h.	1 YEAR + 1 month	...	...
20	" 2, "	[10 $\frac{1}{8}$]†	♀	...	...	9 months.	Was berried in July 1904.
21	Oct., 1903.	11 $\frac{3}{4}$	♀	...	...	1 YEAR.	
22	" 1904.	...	♀ e.h.	2 months.	...	...
23	" "	...	♀ e.h.	2 "	...	...
24	" 12, 1904.	11 $\frac{1}{4}$	♀ e.h.	2 "	...	...
25	" 29, "	10 $\frac{7}{8}$	♀ e.h.	2 "	...	...
26	Nov. 1, "	11	♀ e.h.	3 "	...	...
27	" 21, "	...	♂	...	7 months.	...	

* Cast at Dunbar.

† Size of soft lobster.

The total number of casts recorded above is 27. They occurred in the months of April, July, August, September, October, and November. A summary of the casts is here introduced.

[TABLE.

TABLE SHOWING THE NUMBER OF CASTS IN EACH MONTH.

	Sex.	April.	May.	June.	July.	August.	September.	October.	November.
Number of Casts of each Sex {	♂	1	..	..	1	..	..	..	1
	♀	11	2	5	5	1
Total for month ..		1	..	..	12	2	5	5	2

So far as the class of female lobsters here dealt with is concerned, there are two fairly distinct casting seasons. One, which is at its maximum in July, claimed those females which were not berried during the previous winter,* while the second is an autumn casting season, the principal months being apparently September and October. In the autumn season those females that were berried during the previous winter and spring cast ;* that is to say if they cast at all during that year. The two seasons overlap, however. On September 2nd one of the first class of lobsters cast, and the list includes, for August, one of each class.

The two cases in which the lobsters cast two years in succession, viz. Nos. 11 and 12, are interesting, from the fact that the view has been held that the adult lobster would not cast two years in succession: Appellôf maintains that view. The frequent castings of Brook's specimens and of the two males recorded above are important as indicating a possible divergence in rate of growth from the female.

It certainly seems that in captivity the casting process becomes more frequent than in the case of the lobster in the sea. The inactive existence of the creatures, and the absence of any search or exertion on their part in the quest for food, may have predisposed them to vegetate in place of reproducing. The food supplied was not excessive in quantity ; it consisted of shelled mussels (*Mytilus edulis*) and fish.

The Increase in Size on Casting.

One fact has been noticeable in connection with the moulting that occurred at the Laboratory, and that is the small increase in size that has followed the casts.

It is sometimes difficult to accurately measure the moulted shell, owing to the rupture of the connection between the carapace and the abdomen which occurs during the change, but care was taken to replace the parts as nearly as possible in their natural relationship before measurement. In the following Table the sizes of the lobster before and after the moult are set forth. As a rule, the soft lobster was measured within a day or two of the cast. All the lobsters in the Table are females. The lobster is measured from the tip of the rostrum to the hind edge of the telson.

* There was one exception. One female which was berried during the winter cast in the July following. *Vide* p. 87.

No.	Month.	Size (inches) before Casting.	Size (inches) of Soft Lobsters.		Immediate Increase in Size.	Length of Time in Captivity.
			Measured just after the Cast.	Measured after an Interval.		
1	July.	12 $\frac{7}{8}$	12 $\frac{7}{8}$	13	Inch. 0	1 YEAR.
2	"	12 $\frac{1}{4}$	12 $\frac{3}{4}$	12 $\frac{7}{8}$	$\frac{1}{4}$	"
3	"	10 $\frac{3}{8}$	10 $\frac{7}{8}$	..	$\frac{1}{4}$	"
4	"	12 $\frac{3}{4}$	13	.	$\frac{1}{4}$	2 YEARS.
5	"	11	11 $\frac{1}{4}$	..	$\frac{1}{4}$	"
6	"	11 $\frac{1}{4}$	11 $\frac{3}{4}$	..	$\frac{1}{4}$	1 YEAR.
7	"	11 $\frac{3}{8}$	11 $\frac{1}{4}$	..	$\frac{3}{8}$	"
8	"	12	12 $\frac{1}{4}$	..	$\frac{1}{4}$	"
9	Sept.	11	11 $\frac{3}{8}$	..	$\frac{3}{8}$	"
10	"	9 $\frac{1}{2}$	..	10 $\frac{1}{2}$	..	1 month.
11	Oct.	11 $\frac{3}{4}$	12	..	$\frac{1}{4}$	1 YEAR.
12	"	10 $\frac{8}{8}$	11 $\frac{3}{8}$	..	$\frac{5}{16}$	2 months.
13	"	11 $\frac{1}{4}$	11 $\frac{1}{2}$	..	$\frac{1}{4}$	2 "
14	Nov.	11	11	..	0	3 "

These figures indicate that there was no great increase in size just after the cast, whatever may happen during the time that the shell is hardening. Herrick found that the lobster grew considerably during that time. While most of the lobsters mentioned in the Table had been in captivity for a year or more, there are four cases in which the length of confinement was only that of a month or two. In the case of one lobster, the increase in size nine months after the moult was one inch. In the other short-period cases the increase was just as small as with the lobsters which had been over a year in the Laboratory. In two cases, in fact, the soft lobster was, as far as could be ascertained, exactly the same size as the hard lobster. It was not possible to separate all the soft lobsters and measure them subsequently to see what increase took place during the hardening of the shell. In the case of the first two lobsters, which were re-measured, after intervals of two and one week respectively, an increase of $\frac{1}{8}$ inch in each case took place. Ehrenbaum agreed with the earlier observations of Herrick and Rathbun in noting the slowness in the growth of the older lobsters. He instances a case where a lobster, measuring 40.2cm. (16 inches) in length, only increased its length by a millimetre ($\frac{1}{25}$ inch) on casting. Vitzou gives measurements to show the increase that takes place in different parts of the body after casting; he demonstrated the fact that while the carapace and abdomen increased in size at once, the large claws only showed a marked increase 17 hours after the moult.

Salter describes in detail the operation of casting. The lobster cast in July. Immediately after it had got rid of its shell it concealed itself among a mass of seaweed that it had before casting collected in a corner of the tank. Brook observed that a male lobster buried some food before casting, and after another cast it partially buried its cast integument in the sand.

THE HARDENING OF THE SHELL.

The shells of the soft lobsters hardened only very slowly, in this respect differing from cases reported by other observers. A male lobster that cast when in a box floating in Dunbar harbour in July 1902 was 33 days later hard. It had lost nearly all its pereopods, and so had difficulty in walking. It arrived at the Laboratory on September 30th, and lived there until December 30th 1902. Herrick says that six to eight weeks are required to complete the hardening process, a period also given by Prince. Ehrenbaum gives a period of from three to four weeks. Meek records a lobster that, having cast on September 12th, regained its hardness of shell in one month.

The lobsters in the Laboratory were not eager for food immediately after the moult. The food was shelled mussels usually, with fish occasionally. The integument, once it became stiffened, remained for a long time more or less pliable, as if the calcified layer of the shell were poorly developed. Whether the slow hardening is due to the nature of the food or of the sea-water is not known. The shells, many months after the cast, were deficient in lime and cut easily like brown paper.

The lobster that cast on September 22nd 1902 was still soft to the extent that the integument is flexible and yields to pressure, when it died, viz. on June 6th 1903. Another which cast about the middle of August was fairly hard a fortnight later. Three lobsters which moulted in July 1903, and one that moulted in August of the same year, were in the following July 1904 still softish in the shell. They were in good condition, for two of them cast during that month. The fact, then, that their shells had not become as hard as that of the lobsters caught in the sea, did not apparently constitute any weakness in the animals.

A female which cast on 19th October 1903 was fairly hard on December 30th 1903. One of the casters of 1904 was kept until April 2nd 1905, when it was found dead. It was fairly hard, but the carapaces and integument of the abdomen cut easily with a knife. On the shell there was a considerable number of the shells of an annelid. The colour of the carapace was a dull black. It is possible that the food supply is not sufficiently varied to supply all the materials necessary for the building-up of the shell.

One of the lobsters that cast in July 1903 was on October 21st 1904 not very hard. It was found dead on February 17th 1905, and it was then hard.

A female lobster cast in July 1904; on May 6th 1905 it was still rather soft.

The shell of a soft lobster, when put into alcohol, turns red; the colour of the hard shell—blue-black—is not affected by the alcohol.

INDICATIONS OF APPROACHING MOULTING.

When the stock of lobsters was examined on 21st October 1904 one of the lobsters, a female, that had hatched its eggs a month or two previously, attracted attention. The carapace was raised posteriorly and separated a little from the first abdominal joint; the skin between the carapace and the abdomen was bulged out. Ventrally the soft parts between the abdominal segments were turgid. The absorption areas on the chela were a deep bright blue, and yielded a good deal to pressure, showing that absorption of the calcareous layer had been going on there. The lobster was separated from the others, and it cast on November 1st.

On 29th October 1904 a female cast. It had been isolated a short time before. It was then very limp, and half dead in appearance. It was swollen at the junction of the carapace with the abdomen, and somewhat dropsical in appearance. It was not at all smart with its chelæ.

Ehrenbaum says that the lobster merchant is able to distinguish a lobster that is about to cast, by the softening of the ventral edges of the carapace.

THE CAST SHELL.

The colour of the dactyls of the chelæ is noticeable. The back edge of the dactyl is clean and purple in colour, and the pores are well marked. The cast stomach is empty. There is a glairy skin under the carapace, and united to the membranous lining of the integument of the abdomen. It ruptures easily, and is often found sticking out as a fold at the junction of the thorax and abdomen. Vitzou, who witnessed the moulting of the lobster, describes this skin as a homogeneous, gelatine-like layer, which, under the microscope, shows no cellular structure. It is, he says, a secretion of the lower layers of the new carapace; it passes out by endosmose to lie between the old shell and the new integument. Its presence there facilitates the casting.

THE SOFT LOBSTER.

The soft lobster, when just cast, is extremely soft and pliable; the tip of the chela can be made to touch the telson. The stomach is full of little ossicles, which are derived from the breaking-up of the gastroliths. The lobsters at the Laboratory very often failed to rid themselves of their integument. A considerable number died from this cause.

A lobster that moulted on September 22nd 1902 was kept in one of the compartments of a wooden hatching apparatus until October 14th 1902. When in the wooden box it had not eaten food (fish) at all eagerly. It was at the latter date put into a tank, the bottom of which was covered with sand and gravel. It began immediately to eat small pebbles and gravel. Hard lobsters also have been occasionally seen picking up coarse gravel with the pereopods and putting it into their mouths.

When a lobster casts in a tank in which there are other lobsters it is usually attacked by them, sometimes before it has finished casting, and it is sometimes fatally injured. A soft lobster occasionally bleeds to death in consequence of what appear to be comparatively slight wounds. On July 15th a lobster was found to have lost both chelæ in moulting; it had been attacked and had cast off both claws. One chela was shrivelled just as it is when it is first withdrawn from the shell, and before it has swollen out. The other chela had swollen out to its full size. Both claws were cast off at the fracture plane. Couch observed that "the rejection of the limb can be effected with the same ease while the crust remains soft after exuviation." This fact militates against the view that strong rigid supports are necessary round the fracture plane to permit of the defensive mutilation on the part of the crustacean.

In another case a hard lobster had lost one chela, and the other bore the scar of a bite. During moulting the scar prevented the withdrawal of this limb, so it was thrown off at the fracture plane. A bud had formed in place of the previously lost limb, and after the cast a diminutive chela was present; the hand (propodite and dactylopodite) measured $2\frac{1}{2}$ inches long, while the normal-sized hand measures 4 to 5 inches. Brook

found that the lost smaller pereopods were reproduced to their full size after one cast.

RATE OF GROWTH.

Coste* stated that the lobster begins to reproduce in its fifth year. It casts from eight to ten times in the first year, five to seven in the second, three to four in the third, and from two to three in the fourth. After the fifth year the changes are only annual.

Recent researches on the rate of growth of the European lobster by Appellôf are summarised in a recent number of the *Fish Trades Gazette*.† A lobster, hatched in 1900, cast on 20th June and 5th September 1902, and at the latter date measured $3\frac{1}{2}$ inches long. In the following year it cast on 22nd June and 21st August, its length then being $4\frac{1}{2}$ inches; it was then three years old. Another lobster, when caught in 1901, measured $4\frac{3}{4}$ inches; it cast twice in 1902, and measured 7 inches. In 1903 it cast once, and was then $8\frac{1}{2}$ inches. Appellôf concludes that the lobster on the west coast of Norway takes six or seven years before it reaches a length of $8\frac{1}{2}$ inches, that is to say, maturity. The number of casts which have occurred up to that stage is 17 to 19. Meek concludes that the lobster is 9-10 inches long when four to five years old.

Herrick considered that the American lobster when 10 inches long was about $4\frac{1}{2}$ years old. In the *32nd* and *33rd Reports of Commissioners of Inland Fisheries of Rhode Island* certain data are given bearing on the rate of growth of that lobster. A method of rearing the larvæ in cloth bags was found to be very successful, a whirling motion was maintained in the water while the lobsters were in the zoea condition. Lobsters were reared from the zoea condition and kept until over two years old. The following are the average sizes at different ages:—

3 months old	..	$1\frac{3}{8}$ inches long.
10 ,,	.. av.	2 ,,
1 year	.. ,,	$2\frac{1}{8}$,,
2 years	.. ,,	$4\frac{1}{2}$,,
2 years + 4 months	..	$4\frac{7}{8}$,,

THE BEHAVIOUR OF THE LOBSTER.

The main motive of a lobster's activity is defence—caution; and, in defending itself, a blind unrelenting vengeance is a fitting corollary. It first procures a hole within which to lie waiting for its prey, and to which it may retire after a foray. Any animal that approaches it is a foe. No animal, lobster or other, is safe to approach and make its presence known. In this highly organised form, its keenness in attack, and relentless hold when it once has gripped its antagonist, are due to its want of sight. The want of sight, in its true sense, in the lobster and crab places a disability on them, and reduces the effectiveness of animals which would otherwise be powerful competitors of the smaller inhabitants of the sea. Herrick says that the eye of the lobster is so sensitive to light that it cannot bear strong light; strong light blinds it. One immediate difficulty then which is experienced in keeping lobsters in confinement is their tendency to fighting, which usually results in the loss of a chela to one of the combatants. When a lobster is seized by its big

* *Vide* Buckland.

† July 9, 1904.

claw it very often has to yield it up, whereupon the other unconcernedly drops it. Lobsters which have been confined together show many traces of the attentions that have been paid to one another. The chela is, in many cases, missing, or, if it persists, has one or more scars of bites, which had crushed through the shell. Very few of the lobsters have anything but short stumps of their antennæ, these organs having been snipped off more or less close to the head by their companions. These accidents usually happen when the lobsters are wandering about seeking for dark corners and sheltering holes. After they have settled down in their holes they stick to their habitations and do not come so much into competition with one another. When they are first introduced into a tank it is well to have the big claws tied, and by the time the claws work free their owners will have settled down in their new quarters. If there is sufficient accommodation in the form of holes of inviting darkness, they will soon get peacefully distributed; but at first a lobster will sometimes try to evict one lobster from the hole which it has selected as its abode. One lobster was seen to yield up the recess, which was immediately taken possession of by the aggressor.

On each occasion when the tank is emptied for cleaning, and for the purpose of examining the lobsters, it is usually necessary to disturb the shelter-holes, which are formed with stones. When the tank is filled again the lobsters do not seem to recognise one another at once. They go cautiously about seeking shelter, on the watch for foes and ready to fight any lobster they may meet. Under such conditions, then, it is not surprising that chelæ are lost, or some other injury incurred, before they are all satisfied as to hiding accommodation. When they settle down they allow for one another's presence and get on without quarrelling. This is, of course, due to a healthy respect which they have for one another's fighting powers. The truce is nothing but an armed neutrality. If any one of the lobsters loses its fighting power through casting its shell, it is at once attacked. And that occurs in cases where lobsters have lived together for months. Four lobsters were in a large tank undisturbed for four months. When the tank was emptied each lobster was handled. Two days after the tank had been refilled the chela of one of the inmates was lying loose on the sand.

More especially do the lobsters take advantage of any one of their number that casts its shell. Very seldom does the soft lobster escape without serious injury. Female lobsters attack a soft female. The male which cast in November 1904 was so injured by the female which was with it in the tank that it bled to death. How a male would act towards a female that cast in its presence was not indicated during the experiments, as that case did not occur.

A female lobster that cast on July 13th 1904 had a hard male lobster introduced into the box in which it was. The male did not appear to mind the listless and inactive female; it certainly did not attempt to grasp it or fight it. On July 19th the female was found to have been bitten in the cephalic region; one chela had been lost and one or more of the remaining pereopods bitten off. This is very different treatment to that meted out by the male crab to the moulted female. In the latter case the male protects her.

The extremely defenceless condition of the soft lobster was especially seen in one case. A female that moulted in August had lost both chelæ. It was kept by itself until October, by which time it had become fairly hard. A lobster that had just cast had both chelæ, but was very soft. The two were put together into a small tank. In a few days the soft lobster was found dead; its antennæ, eyes, and part of one chela were eaten off.

Peculiar Action of a Group of Lobsters.

On October 29th the four female lobsters which cast during the summer were very restless. They were walking about in the tank, or standing, as it were, on tip-toes, and having the abdomen bent, with the edge of the telson close up against the fifth pereopod. Occasionally they extended the abdomen and moved the swimmerets backwards and forwards. The male lobster which is with them was also out of his hole, standing on tip-toes, with the abdomen extended straight out and moving his swimmerets actively. The lobsters appeared to be quite friendly, and did not attempt to bite one another. The supply of water running into the tank was not very large at this time. Whether this had in any way influenced the action of the lobsters is an open question. It had not been observed before.

THE SENSES OF THE LOBSTER.

The lobster when it walks has the telson turned in on the abdomen, and it marches on the "points of its toes," backwards as well as forwards. It is practically blind; it sees nothing properly, at least that is the case where it is exposed to the comparatively strong light which during the day illumines the tanks in the Laboratory. It has simply the sensation of light and shadow. It tests a shadow with its antennæ, or sometimes where a strong shadow is thrown on it, it jumps at it with its chelæ outstretched and snapping. It is dependent on its antennæ for guiding it in safe places. It is especially careful in testing any hole before it is satisfied with it. It discovers the cavity by means of its antenna, which is waved well out to the side and in front as it walks. It searches the innermost depths of the hole with the antenna, and then inserts its chela. If the examination with the chela is also satisfactory, it immediately turns and backs smartly into the hole. In feeding it is guided to the food by the antennules. A piece of food which is dropped near a lobster may fall quite unnoticed unless it happens to touch the antenna or the pereopods. It is not seen at all. But sooner or later, according as the distance is short or great, the scent of the food, carried by the currents set up by the exopodites of the maxillipedes, reaches the lobster. The lobster is immediately excited, although previously it was lying quite inert in its hole. It whips the water with its antennules in a staccato fashion, and feels about with the antennæ and chelæ; at first without leaving its hole. At once both antennules are seen to be whipping in the direction in which the food is lying, and an active search is made with the antennæ. If they do not succeed in locating the bait, the lobster rather reluctantly leaves its hole, but cautiously, feeling all round about with its antennæ. It goes off straight in the direction in which the food is lying, and if it misses it with its antennæ and chelæ, walks over it and gets it with its chelate pereopods; it usually picks up its food with the second pereopod. Meanwhile the expected feast has by association stimulated the maxillipedes, which are actively working as if they were already masticating the food. Once the food is seized it is conveyed to the maxillipedes, and the lobster retreats to its hole, there to enjoy its meal. Two lobsters were noticed to have stored up in one case some mussels, in the other a dead sand-eel (*Ammodytes tobianus*), in the inner recesses of their caves.

EFFECT OF COLD ON LOBSTERS.

In the winter the lobsters kept in the tanks of the Laboratory became very sluggish, and ate very little if any food. When taken out of the water and exposed to the frosty air they become very inert.

THE EFFECT OF THE EXPOSURE OF THE LOBSTERS TO STRONG LIGHT.

A number of lobsters have been kept out of doors, in tanks which were without covering. In two of the tanks the bodies of the lobsters were hidden by the wooden shelf which formed the common roof to their pens; one large concrete tank afforded them no cover whatever. In the former the antennæ of the inmates were exposed to direct daylight, and they very often had pieces of seaweed and smaller ectozoa growing on them during the summer. Two females were kept in the concrete tank from the autumn of 1902 till September 1903. At the latter date they were completely covered and hidden by a prolific growth of seaweeds, *Laminaria* sp., young mussels, &c., which completely occupied the dorsum of each shell-fish (*vide* fig. 73, pl. iv.). The covering appeared to be of some inconvenience to the lobster in walking. While the growth of the seaweeds was, no doubt, directly due to the exposure to daylight, it is probable that it was permitted by the host as a shelter in the exposed tank. The shells of the pair were clean when they were put into the tank. Herrick records examining a number of lobsters which were adorned with more or less extensive collections of seaweeds and other ectozoa. On none of the lobsters captured in the sea and sent to the Laboratory was there any coat of seaweed. The ectozoa usually consisted of tubes of *Serpula* sp., *Balanus* sp. One of the two cast its shell on 19th October 1903, and a drawing has been made from the cast shell (fig. 73, pl. iv.). It lived until May 1904. The other lobster did not cast, but remained covered with seaweed during the winter; it also was found dead in May 1904.

BODY FLUID.

The body fluid of the lobster is richly albuminous. It is colourless when fresh, but soon coagulates on exposure to air to a clear jelly with a slightly brown tint. Alcohol (94 per cent.) causes the blood to coagulate at once.

DISSECTION.—EXAMINATION OF THE OVARY.

Almost without exception, the ovaries of the lobsters examined, measuring 9 inches and over in total length, were found to contain eggs as large, or nearly as large, as ripe eggs. When the eggs are large, yolked, and approaching ripeness the ovary is black in colour; the eggs themselves are black, although the yolk is really a very dark-green colour. The ovary turns red in alcohol.

The lobsters were broadly distinguished as (a) berried, (b) lobsters which had lately hatched their eggs, (c) soft.

(a) *Berried Hens.*

(1) December 21, 1904.—A lobster (from Dunbar) measured $11\frac{1}{2}$ inches in length. The shell was clean. The external eggs were black, showing no pink-coloured part, simply a light-green formative part. The eggs were evidently early. The ovary was white, but contained green eggs measuring .4 and .5 mm. The smaller green eggs contained simply a core of green yolk, surrounded by a periphery of white yolk (by transmitted light). The oviducts were filled with a greenish fluid.

(2) February 19, 1905.—In a lobster (from Dunbar) the external eggs were well advanced; the pink area was about one-fifth of the whole egg. The ovary was large and black in colour.

(b) *Lobsters which were not carrying eggs, but which had HATCHED their eggs in the summer preceding the date of examination.*

(1) December 2, 1902.—Lobster 10 inches long. The shell was dirty, encrusted with *Serpula* sp. The ovarian eggs were large, black, oval in shape, measuring $1.5 \times 1.3 : 1.4 \times 1.3 : 1.35 \times 1.3 : 1.45 \times 1.3$ mm. There were also rows of white eggs between the large eggs. The ovary is mottled here and there on the surface with yellow bodies, which appear to be fat masses.

(2) December 1, 1902.—The ovary of another adult was all over externally of a uniform dull black colour.

(3) December 28, 1902.—A lobster measuring $10\frac{3}{4}$ inches in total length had been two days in formaline before it was examined. The ovaries were large, black, with a tinge of green. There were some white and some yellow small eggs scattered over the surface between the large eggs. The large black eggs measured $1.45 \times 1.35 : 1.32 \times 1.3$ mm. They were polygonal in shape, and stood out boss-like on the surface of the ovary. The smallest yolked eggs were white, the intermediate in size yellow; even some very large eggs were yellow. The yellow colour was probably due to the introduction of the green yolk into the white eggs. From the burst eggs it was seen that the yolk consisted of minute green corpuscles, and also a large quantity of colourless fat corpuscles. The chorion of the egg is very thin and easily ruptures. There were a few small eggs yellowish white in colour measuring $.8 \times .65$ mm. The yellow bodies in the ovary measured about $1 \times .85$ mm. The outer skin of the ovary is very thin.

(c) *Soft Lobsters.*

(1) A lobster that hatched its eggs in the summer of 1903 cast its shell and died during July 1904. It appeared to be well nourished. The ovary was large; the eggs measured $1.75 \times 1.4 : 1.7 : 1.65 \times 1.4 : 1.5$ mm., &c. They were irregular in shape and very soft. A portion of the ovary was cut out and flicked about in sea-water with a camel-hair brush, and the eggs separated easily from the follicular tissue, in which were the yellow bodies noticed above.

(2) A lobster that hatched its eggs in the summer of 1904 cast its shell in September 1904. It was killed by the other lobsters. The ovary was large, dark-green in colour, and friable; the eggs readily detached themselves from the delicate follicular membrane. They were irregular in shape, and measured $1.35 \times 1.15 : 1.15 : 1.9 \times 1.5 : 1.4 \times 1.35 : 1.35 \times 1.25 : 1.3$ mm.

(2-4) Three others which hatched their eggs in 1904 cast and died in October 1904. In each the ovary was large and the eggs apparently ripe.

(5) Another hatcher of 1904 stock was found dead on October 23rd 1904. The ovary was large and full, each egg being sharply separated off from the others. When viewed with a lens the surface of the ovary had a honeycomb appearance. The eggs separate readily from the follicular tissue.

(6) A sixth of this lot was found dead on November 16th 1904. The ovary was large, black, with apparently ripe eggs.

(7) A 1902 hatcher cast in 1903 and also in July 1904; it died immediately after casting. The ovary was to all appearance ripe.

(8) Another 1902 hatcher cast in 1903 and lived till August 1904, when it was killed. On dissection it was found to be in apparently good condition. The ovaries were large, and the eggs appeared to be ready for spawning.

(9) A third specimen of the 1902 stock which had cast in 1903 was kept until February 17th 1905, when it was found dead. The ovary was large and black. The eggs appeared to be ripe, and had at one pole a clear green cap.

(10) The last survivor of the 1902 lot died on April 2nd 1905. It had cast in 1903 and also in 1904. The ovary was large, black; but otherwise the lobster appeared to be poorly nourished.

HARD LOBSTER.

A lobster which was not berried when captured was dissected on December 1st 1903. It measured 11 inches in length. The shell was clean, black. The ovary was black. The eggs were yolked, but only about half the diameter of ripe eggs. The eggs separated fairly freely, and measured $1 \times .8 : .72 \times .65 : 1 \times .9$ mm. These were black yolked eggs. There was also a considerable quantity of white eggs, all small and of various sizes; the largest of those noticed was oval, and measured $.45 \times .3$ mm.

Meek records a lobster measuring $11\frac{1}{2}$ inches in length which hatched its eggs in the beginning of July and lived till September 12th 1901. The ovary was dark green, and was well developed. It exhibited no signs of preparation for casting.

SPAWNING.

Of all the adult female lobsters which have been kept at the Laboratory during the past three years, only one was known to have spawned. Some of those which were from time to time dissected had ovaries which were practically ripe. The lobsters were kept for longer or shorter intervals. One batch of females which were berried in 1902, and which hatched their eggs in the summer of that year, were represented at the Laboratory till April 1905. No member of this group showed any eggs attached externally. That they were not altogether unhealthy was shown by the fact that they nearly all moulted once, in two cases twice, during the period named. So it was with the other females; they cast readily, but did not succeed in spawning, or, if they spawned, the eggs did not become attached. Moreover, none of those dissected had a spent ovary. In the case of the adult crabs some spawned, but in one or two of these only a few eggs became attached.

The lobster which became berried was received from Dunbar in December 1902, at which time it was not berried. It cast its shell on September 2nd 1903. On January 13th 1904, when it was examined, it was not berried, but on July 14th a small quantity of eggs were found attached to the swimmerets. The eggs were early and apparently just spawned; they were dark-green with a clear granular area on one side. This lobster was not with a male lobster when it spawned. On October 21st 1904 there were only two eggs remaining attached, and when it was examined on November 19th 1904 the remaining two had disappeared.

As to the time when spawning takes place, Ehrenbaum gives the period covering July, August, and probably September. Fullarton obtained lobsters with very early eggs—yolk unsegmented—between July 18th and August 25th. Herrick says, for the American lobster, that the definite spawning season is the summer, July and August, but that a minority extrude their eggs in the fall and winter, if not also in the spring. Allen obtained females with freshly extruded eggs during the latter half of July. Appellôf agrees with the period announced by

Ehrenbaum, but extends it to the middle of October. Meek found newly-spawned lobsters in July and August. The lobster which spawned during Cunningham's experiments in Cornwall did so in October, and Scott's specimen extruded its eggs during the same month at Piel Laboratory.

There is thus indicated an extended spawning season, including the months of July, August, September, and October. It may be that there are here two distinct groups of spawners—summer and autumn spawners—the first including lobsters that were not berried during the winter immediately preceding, while the autumn spawners are those which were berried during the winter, hatched their eggs in the summer, and extruded another batch of eggs in the autumn.

The question whether or not the European lobster may carry external eggs two years in succession does not arise, Cunningham's observation, confirmed later by Scott's description of the process, having demonstrated that possibility. As for the American lobster, Herrick maintains, in a later work, the position taken by him on this question in 1895. He founds his contention that the American lobster does not carry eggs externally two years in succession on the condition of the ovary in various lobsters which had lately hatched the eggs. He maintains that the ovary requires two years to develop to ripeness.

The factors which determine the spawning of the lobster are obscure. It is remarkable that only one lobster spawned in the Laboratory, although in several cases the ovaries of specimens which were dissected were apparently ripe. The rate of development of the ovary is dependent on some factor that is not apparent. The ovaries referred to would probably have been completely ripe in a short time. The complete ripening seemed to be inhibited by some influence, which might have been the absence or insufficiency of male lobsters. Even where a male lobster was present with the female spawning did not take place, and when the one lobster spawned no male was present. Otherwise the lobsters, it may be inferred, were under comparatively suitable conditions, for there was an uniformity shown in their history while in confinement. Moulting was common. What is the reason for the abstention from spawning? The artificially-supplied food may have induced growth rather than reproduction.

The lobster may spawn the same year in which it has cast its shell. Trybom's experiments* in labelling lobsters in order to determine their migrations indicated two females, measuring $8\frac{1}{2}$ inches long, liberated in June, had in November cast their shells and spawned; they then measured a little over 9 inches in length.

The actual modus of spawning has been described by Coste, Scott, and others.

Ehrenbaum describes a condition of the lobster which follows when a ripe lobster has been prevented from spawning. The eggs are absorbed and the blood becomes dark green or black in colour. The dark blood shows through at certain parts of the body and the lobster is known as a black lobster. Lobsters in this condition are found among those confined in floating boxes. The ovaries are much reduced in size, and the majority of the eggs have lost the green yolk, and have become of a yellowish colour.

The Ripe Egg and the Formation of the Perivitelline Space.

The ripe egg, newly spawned, was measured by Scott and found to be 1.8mm. in diameter.

**Fish Trades Gazette*, July 30, 1904.

During the examination of the ovaries of the lobster no case was found in which the eggs showed a perivitelline space when in the ovary. Large ovarian eggs, however, as a rule, develop a perivitelline space if left some time in sea-water. A lobster that cast on July 9th 1904 died five days later. The ovarian eggs measured $1.75 \times 1.4 : 1.7 : 1.65 \times 1.4 : 1.5\text{mm}$. The eggs were teased out in sea-water and two or three hours afterwards showed considerable perivitelline spaces. The space usually shows more on one side than on the other; it is clear and colourless.

A lobster that hatched its eggs in the summer of 1904 and cast immediately afterwards was dead on October 23rd 1904. Some ovarian eggs were separated and put into sea-water. An hour afterwards the eggs, in most cases, showed a more or less well-marked perivitelline space. Next morning the eggs kept in the sea-water overnight had very large perivitelline spaces. The eggs were yellow—dead.

The egg of the lobster has two envelopes:—(1) Outside—the chorion. (2) Within the chorion, and closely applied to the egg—the vitelline membrane. This envelope is well seen sometimes when a perivitelline space has been developed in sea-water.

The External Eggs.

When the eggs are just spawned they are of a deep greenish black in colour, with a little clear area at one pole. As development proceeds, the clear area becomes pink in colour, and by the month of October in some lobsters the future limbs and the black pigmented eyes were already made out. The transparent pink area steadily grows larger at the expense of the black yolk, until, when the eggs are nearly ready to hatch, the black yolk may be reduced to half, or even much less, of the mass of the egg. The black yolk occupies the cephalic and gastric regions in the larva.

The external eggs measured on May 17th were of the following dimensions:— $2.2 \times 2 : 2.15 \times 2.1 : 2.1 \times 2.05 : 2.25 \times 1.95 : 2.25 \times 2 : 2.15 \times 2 : 2.1 : 2.1 : 1.95 \times 1.9 : 1.95\text{mm}$. The eggs are, for the most part, oval. They were well developed, the pink area being about one-fifth of the whole mass of the egg. In some of the eggs examined in June the black yolk had disappeared; most of the eggs showed a large mass of black yolk.

When ready to hatch, the eggs are of various colours, viz. transparent pink, transparent blue, transparent green, except for the black area which marks the yet unused-up yolk. The largest eggs show the least black area; in them the black has practically disappeared. The eggs increase greatly in size before hatching, and at that time it is difficult to dissect them off the swimmerets without rupturing the zona radiata. The following measurements of various eggs were made in August 1902; the eggs were, as a rule, distinctly oval in shape:—

Pink egg,* 2.5mm .; pink eggs, $2.8 \times 1.95 : 2.4 \times 2.15 : 2.35 \times 2.25\text{mm}$.

Egg, blue and yellow, $2.5 \times 2.45 : *3.2 \times 2.55 : *2.9 \times 2.4\text{mm}$.

Egg, deep blue, $2.35 \times 2.3\text{mm}$.

Egg, red, $2.05 \times 1.9 : *2.9 \times 2.6 : *3.15 \times 2.8 : 2.8 \times 2.6\text{mm}$.

In the last egg the heart of the embryo was seen beating.

The Number of External Eggs.

Buckland calculated the number of eggs borne by a female. He first counted the number on one foot and from that deduced the total. This was 24,960 eggs. Ehrenbaum found that the larger the

* Zona ruptured.

lobster the larger the number of eggs which it carried. A lobster 10 inches long had 8000 eggs, while one 15 inches in length bore 32,000. Herrick found in the American lobster that the number of eggs varied from 3000 to 70,000. The eggs of two lobsters were estimated at the Laboratory in the following manner:—They were snipped off the swimmerets and dried in a water-bath. A small portion was detached and weighed, the number of eggs in it was counted, and the total number was got from the total weight. One measuring $11\frac{1}{2}$ inches in length, 11,300 eggs, while the other, $12\frac{1}{2}$ inches long, had the same number.

It is remarkable that so small a number of fry was obtained from the parent lobsters kept in the Bay of Nigg. This is partly accounted for from the fact that a greater or less quantity of the eggs is lost when the berried hens are handled, and during transport. This does not, however, seem sufficient to account for the whole of the shortage.

HATCHING.

Hatching occurred at the Laboratory during July, August, and September. The earliest larvæ appeared about the middle of July, the majority hatched in August, and a few in September.

According to Coste* hatching takes place in March, April, and May. Allen records that hatching took place in one instance in March. Fabre-Domergue, and Biéatrix† observed the hatching of the lobster, and describe the process in detail. The larvæ issue early in the night.

The whole brood of any one female does not hatch out at once, but over a period, the larvæ issuing in two or more batches (*vide* Coste, Herrick, and Fullarton). The incubation period, according to Ehrenbaum, Herrick, and Fullarton, is about eleven months. During an incubation period so extended it is to be expected that a certain variation will have occurred in the point of development reached by different eggs. This would result in spreading the hatching of the eggs over a period which probably does not usually exceed a fortnight or three weeks. The first larval lobsters were observed on July 11th, and one of the females was found to have hatched all her eggs on August 2nd. The larvæ usually appeared in the morning.

MEASUREMENTS OF THE LOBSTER.

Occasionally lobsters are measured by the length of their barrels, *i.e.* of the carapace, from the extremity of the rostrum to the hind border. In several cases the relation between the total length and the length of the barrel has been noted, and the data are entered below.

Total Length of Lobster.	Length of Barrel.
♀ $9\frac{1}{2}$ inches.	$4\frac{3}{16}$ inches.
♀ $10\frac{5}{8}$ "	$4\frac{7}{8}$ "
♀ 11 "	$4\frac{3}{4}$ "
♀ $11\frac{1}{2}$ "	$5\frac{1}{16}$ "
$12\frac{1}{2}$ "	$5\frac{1}{2}$ "
♂ 13 "	$5\frac{5}{8}$ "

* *Vide* Buckland.

† *Fish Trades Gazette*, Sept. 26, 1903.

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LIST OF LETTERS AND FIGURES USED.

I., Ia., II., III., “IV.”=First to “Fourth” Zoëa Stages.

1, 2, 3, 4, 5, 6, 7=Joints of Limb, viz. (1) Coxopodite, (2) Basipodite, (3) Ischiopodite, (4) Meropodite, (5) Carpopodite, (6) Propodite, (7) Dactylopodite.

a.—Antennule.

A.—Antenna.

ab.—Abdomen.

en.—Endopodite.

ep.—Epipodite.

ex.—Exopodite.

lr.—Labrum.

lm.—First maxilla.

2m.—Second maxilla.

Mn.—Mandible.

mp.—Maxillipede.

o.—Eye.

1-5 per.—First-Fifth Pereiopods.

Pleo.—Pleopod.

T.—Telson.

Th.—Thorax.

EXPLANATION OF PLATES.

PLATE I.

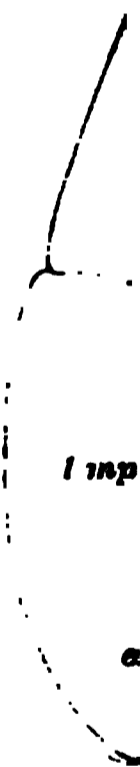
All the Figures are of the First Zoëa.

Fig. 1.	Antenna and antennule,	x	47
Fig. 2.	Antennule,	x	57
Fig. 3.	Labrum,	x	62
Fig. 4.	Eye and rostrum,	x	33
Fig. 5.	Mandible,	x	33
Fig. 6.	Cutting edge of mandible,	x	120
Fig. 7.	First maxillipede,	x	62
Fig. 8.	Third maxillipede,	x	33
Fig. 9.	Second maxilla,	x	57
Fig. 10.	Palp (?) of first maxillipede,	x	175
Fig. 11.	First pereopod (chela),	x	19
Fig. 12.	First protopodite joint and gills of the second pereopod,	x	62
Fig. 13.	Third pereopod,	x	19
Fig. 14.	Epipodite of second maxillipede,	x	220
Fig. 15.	First protopodite joints and gills of the second pereopod,	x	62
Fig. 16.	Third maxillipede,	x	33
Fig. 17.	Propodite and dactylopodite joints of the third pereopod,	x	62
Fig. 18.	Palp of mandible,	x	120
Fig. 19.	Protopodite of the second maxillipede,	x	62
Fig. 20.	Propodite and dactylopodite joints of the chela (first pereopod),	x	62
Fig. 21.	Propodite and dactylopodite joints of the second pereopod,	x	19
Fig. 22.	Second pereopod,	x	175
Fig. 23.	Edge of endopodite of the first maxillipede,	x	57
Fig. 24.	Flagellum of antenna,	x	62
Fig. 25.	First protopodite joint of the third pereopod,	x	62
Fig. 26.	First protopodite joint of the third pereopod (second view),	x	62
Fig. 27.	First maxilla,	x	62
Fig. 28.	Protopodite of the chela (first pereopod),	x	33
Fig. 29.	Second maxillipede,	x	33

PLATE II.

Fig. 30.	Abdomen, zoëa, first stage, ventral view, g =ganglion,	x	19
Fig. 31.	Abdomen, 2nd and 3rd joints, zoëa, first stage, side view,	x	44
Fig. 32.	Abdomen, 2nd and 3rd joints, zoëa, stage 1a, side view,	x	19
Fig. 33.	Abdomen, 5th joint, zoëa, second stage, ventral view,	x	19
Fig. 34.	Propodite and dactylopodite joints of the fourth pereopod, zoëa first stage,	x	62
Fig. 35.	Telson, zoëa, third stage, ventral view,	x	19
Fig. 36.	Cast 4th pleopod of zoëa, third stage,	x	33
Fig. 37.	Abdomen, 3rd and 4th joints, zoëa, third stage,	x	19
Fig. 38.	Protopodite joints of first pereopod, zoëa, "fourth" stage, $2a + 2b$ =2nd protopodite joint,	x	33
Fig. 39.	Protopodite joints of second pereopod, zoëa, "fourth" stage,	magnified.	
Fig. 40.	First protopodite joint of fourth pereopod, zoëa, first stage,	magnified.	
Fig. 41.	Setæ of hind border of telson, zoëa, first stage,	magnified.	
Fig. 42.	Fifth pereopod, zoëa, first stage,	x	19
Fig. 43.	First pereopod, zoëa, "fourth" stage,		
Fig. 44.	Protopodite joints, first (1), second ($2a + 2b$), en =endopodite, ex =exopodite, zoëa, "fourth" stage,	x	33
Fig. 45.	Protopodite, first joint, fifth pereopod, zoëa, first stage,	x	62
Fig. 46.	Telson, zoëa, 1a stage,	x	19
Fig. 47.	Abdomen, side view, zoëa, first stage,	x	15
Fig. 48.	Telson, zoëa, second stage, a =anus,	x	19
Fig. 49.	Side of thorax, zoëa, first stage, showing the arrangement of the gills,		
Fig. 50.	Abdomen, zoëa, first stage, dorsal aspect,		
Fig. 51.	Third pleopod, zoëa, "fourth" stage,	x	57
Fig. 52.	Propodite and dactylopodite joints of fifth pereopod, zoëa, first stage,	x	62
Fig. 53.	Fourth pereopod, zoëa, first stage,	x	19
Fig. 54.	First protopodite joint, fourth pereopod, zoëa, first stage,	x	62
Fig. 55.	One of the serrated spines on propodite of fourth pereopod, zoëa, first stage,		
Fig. 56.	Telson, zoëa, "fourth" stage, ventral view,	x	11

F. B.



1 mp

a

20



1

H. C.

PLATE III.

Fig. 57.	Telson, megalops.	All the setae are not filled in,	.	.	×	19
Fig. 58.	Fracture end of first pereopod,	megalops.	.	.	.	
Fig. 59.	Protopodite joints of first pereopod,	first young stage,	.	.	×	33
Fig. 60.	Protopodite joints of first pereopod,	first young stage (second	.	.	.	
	view),	.	.	.	×	33
Fig. 61.	Fifth pereopod (part of),	megalops,	.	.	.	×
Fig. 62.	Second pereopod (part of),	megalops,	.	.	.	×
Fig. 63.	Telson, megalops,	side view,	.	.	.	×
Fig. 64.	Telson, first young stage,	dorsal view,	.	.	.	×
Fig. 65.	First pereopod,	first young stage,	.	.	.	×

PLATE IV.

[illegible]

III.—OBSERVATIONS ON SOME PARASITES OF FISHES NEW OR RARE IN SCOTTISH WATERS.

By THOMAS SCOTT, LL.D., F.L.S., &c.

Plates V. and VI.

In Part III. of the Twenty-second Annual Report of the Fishery Board for Scotland, I published a small paper on some parasites of fishes new to the Scottish marine fauna. Since the issue of that paper several other rare and interesting species have been examined, and these I now propose to describe.

The species to be described belong for the most part to the Copepoda; but there are also five species belonging to the Trematoda. As these parasitic Copepoda and Trematoda are quite distinct groups, my observations on them are, as in the previous paper, divided into two parts, viz., Part I. Copepoda parasita, and Part II. Trematoda.

I have been indebted for several of the species described here to Dr. H. C. Williamson; Mr. Bowman and Mr. Irvine have also obtained a few interesting species for me. Canon A. M. Norman has also allowed me the privilege to examine one or two rare Copepoda in his collection, sent to him many years ago from the Moray Firth by the late Thomas Edward of Banff.

My son, Andrew Scott, A.L.S., has prepared the drawings which illustrate this paper.

PART I.—COPEPODA PARASITA.

FAMILY ERGASILIDÆ.

Genus *Bomolochus*, Nordmann (1832).

Bomolochus soleæ, Claus.

This species of *Bomolochus* has quite recently been obtained in the nostrils of *Gadus luscus*, which adds another to the number of fishes now known to harbour these Copepods in their nostrils. It was in the nostrils of *Cyclopterus lumpus* that the first specimens were observed, early in 1900, but soon afterwards they were obtained in the nostrils of some other fishes, and notably in those of the cod *Gadus morhua*, where they appear to be of quite frequent occurrence. The fishes in whose nostrils the copepods have been most commonly obtained are those belonging to the gadidæ. The following are the names of the fishes:—*Cyclopterus lumpus* L., the Lumpsucker. *Gadus morrhua* L., the Cod-fish. *Gadus æglefinus* L., the Haddock. *Gadus merlangus* L., the Whiting. *Gadus luscus* L., the Brassie. *Gadus pollachius* L., the Lythe. *Molva molva* L., the Ling. *Pleuronectes platessa* L., the Plaice, and *Pleuronectes flesus* L., the Flounder. *Bomolochus soleæ* was first found on the back of the common Sole—*Solea vulgaris*, Quen.

FAM. CALIGIDÆ.

Genus *Caligus*, O. F. Müller (1785).

**Caligus abbreviatus*, Kröyer. Pl. v., figs. 1-6.

1863. *Caligus abbreviatus*, Kr., Bidrag til Kundskab om Synltekrebsene; Naturh. Tidsskr., 2R., 2B., p. 61, pl. iii., fig. 3, a-k.

Description of the Female.—The Female represented by the drawing, (fig. 1) measures 5mm. ($\frac{1}{4}$ of an inch). The cephalic shield is nearly circular in outline, but is rather widest behind the middle; the width of the frontal plate is scarcely half the width of the cephalic shield at the widest part; lunulæ very clearly defined. Abdomen and furcal joints very short, as represented in the drawing.

The antennules have the basal joints robust and broadly sub-triangular, but the end joints are long and narrow (fig. 3).

The second maxillipeds are robust, and form powerful grasping organs (fig. 5).

The sternal fork, which is moderately stout, and the branches of which are not greatly divergent, has a resemblance to the same appendage in *Lepeophtheirus Thompsoni*, Baird (fig. 4).

The fourth pair of thoracic legs are elongated; the basal joint is moderately stout and one-branched; this branch is slender and composed of two joints, and the end-joint is about twice the length of the first, and is armed with a long, slender and claw-like terminal spine and a short spine near the distal end of the outer margin; the first joint is also furnished with a spine on the outer distal angle (fig. 6).

Habitat.—On a Ballan Wrass, *Labrus bergylta*, captured in the Moray Firth in October 1904, and on another fish of the same species captured in the North Sea. Kröyer also obtained his specimens of the *Caligus* on the Ballan Wrass.

A young specimen representing the *Chalimus* stage of this *Caligus* is represented by figure 2, and was obtained along with the adult form. In this specimen the siphon is still present, showing a somewhat dilated and biarticalated base; the antennules are composed of two short subequal joints, the cephalic shield is elongate-ovate in outline, and the abdomen is very short. The frontal plate slopes posteriorly, and the development of the lunulæ is considerably advanced.

Caligus minimus, A. W. Otto.

1828. *Caligus minimus*, Otto, Nova Acta Acad. Cæs. Leop., vol. xiv., p. 354, pl. xxii., fig. 7.

1840. *Caligus minutus*, M. Edw., Hist. Nat. Crust., vol. iii., p. 450.

1901. *Caligus minimus*, A. Scott, Trans. Liverpool Biol. Soc., vol. xv., p. 349, pl. i., figs. 1-8.

Habitat.—On a Bass, *Labrax lupus*, captured above Queensferry on February 4, 1903. This appears to be the first record of *C. minimus* for the Forth district.

* This species closely resembles, and is probably identical with, *Caligus centrodonti*, Baird. (Of. Brit. Entom., p. 272-3, Tab. xxxii., figs. 6, 7.)

Genus *Pseudocaligus*, A. Scott (1901).*Pseudocaligus brevipedis* (Bassett-Smith).

1896. *Caligus brevipedis*, Bassett-Smith, Ann. and Mag. Nat. Hist. (6), vol. xviii., p. 11, pl. iii., fig. 1.

1901. *Pseudocaligus brevipedis*, A. Scott, Trans. Liverpool Biol. Soc., vol. xv., p. 350, pl. ii., figs. 1-4.

Habitat.—Found attached to the base of the tongue of a Three-bearded Rockling, *Onos tricirratus*, captured at the mouth of the River Dee, Aberdeen, November 23, 1904. Eight specimens of a *Bomolochus*, probably *B. onosi*, were also found on the same fish adhering to the gills and gill-arches.

Genus *Lepeophtheirus*, Nordmann (1832).*Lepeophtheirus sturionis*, Kröyer. Pl. v., figs. 7-14.

1837. *Lepeophtheirus sturionis*, Kr., Tidsskrift, i., Tab. vi., fig. 6.

Description of the female.—The female of this species has a general resemblance to that of *Caligus diaphanus*, Nordmann, but is much larger, being fully half an inch in length (about 14mm.).

The cephalic shield is nearly circular in outline, and the frontal plate, which is not very prominent, is without lunulæ.

The last thoracic segment is considerably shorter than the cephalic shield, and is only slightly longer than broad.

Abdomen moderately narrow and elongated, being equal to nearly three-fourths the length of the last thoracic segment. Furcal joints very short (fig. 7).

The basal joints of the antennules are considerably dilated, and the end joints though short are also tolerably stout (fig. 8).

Antennæ robust and armed with a large and strong claw, the distal end of which is bent at nearly a right angle, as shown in the drawing (fig. 9).

The mandibles resemble those of *L. pectoralis*, O. F. Müller.

The basal-joint of the second maxillipeds is moderately stout and elongate, and armed with a short but strong terminal claw (fig. 11).

The "palpi," though slightly dilated at the base, have the sides nearly parallel, and the two branches of the bifid extremity are tolerably elongated (fig. 10); the small appendage at the bases of the palpi bear each one moderately large spine and two small ones, as shown in the drawing.

Sternal fork very stout and with triangularly divergent branches (fig. 12).*

Fourth pair of thoracic legs stout, each with a single three-jointed branch; the outer distal angle of the first joint in each branch terminates in a small tooth, a stout spine springs from the outer distal angle of the second joint, while the end joint is armed with three terminal spines of varying lengths (fig. 13).

The short furcal joints bear a few small apical setæ or spines (fig. 14).

Habitat.—Taken from a Sturgeon, *Acipenser sturio*, Linn., captured about 16 miles S.E. by E. of Aberdeen, and landed at the Fish Market, Aberdeen, on December 29, 1904. I am indebted to Mr. Bowman, Aberdeen, for this addition to the marine copepod fauna of Scotland.

* Kröyer in Naturh. Tidsskr. 1 Band (1837), Pl. vi., fig. 66, shows the ends of the branches of the sternal fork slightly bifid; but the figure in Naturh. Tidsskr. 3 R., 2 B. (1863), Pl. xvii., fig. 4, represents the sternal fork of another form bluntly pointed at the ends, and with which our figure is identical.

FAM. DICHELESTIIDÆ.

Genus *Dichelestium*, J. F. Hermann (1804).

Dichelestium sturionis, Hermann. Pl. v., figs. 17-24; pl. vi., figs. 1-6.

1804. *Dichelestium sturionis*, Herm., Mem. Aptérologique, p. 125, Tab. v., figs. 7-8.

1837. *Dichelestium sturionis*, Kröyer, Naturh. Tidsskr., 1st B., p. 299, Tab. ii, figs. 5 and 5a (♀).

Description of the Female.—The length of the female represented by the drawing (pl. vi., fig. 1) is 17·8mm (nearly $\frac{3}{4}$ of an inch). Body elongated and narrow; cephalic segment nearly as broad as long, widest behind the middle, sides angulated, truncate, and obscurely trilobed in front. Thoracic segments four, first and second subequal, length equal to about half the breadth, and narrowly rounded at the sides; third segment rather shorter than the one which follows, and each with a shallow transverse suture that divides it into two slightly unequal portions. Genital segment narrow, and about one and a half times the length of the one which immediately precedes it; the ultimate segment ovate, small, being scarcely half the length of the genital segment. Furcal joints short. Ovisac long and slender (pl. vi., fig. 1).

Antennules short, slender, and apparently composed of eight subequal joints (pl. v., fig. 17).

Antennæ robust, extremities chelate, and forming powerful grasping organs (pl. v., fig. 18).

The mandibles resemble those of *Caligus* or *Lepeoptheirus* very closely, but differ in having a stouter basal part, and in the long slender rod-like portion being only three-jointed, the last joint being coarsely serrated on the inner edge (pl. v., fig. 20).

Maxillæ small, two-branched; primary branch stout, tapering distally and furnished with two slender apical setæ; secondary branch very small (pl. v., fig. 21).

The first maxillipeds appear to be three-jointed. The first joint, which is large and tolerably dilated, is about as long as the next two combined; the distal end of the second joint is fringed with short bristles, and the end joint, which is very small, is furnished with a short terminal claw, and a few small marginal spines are shown in the drawing (pl. v., fig. 22).

The second maxillipeds, short, very robust and strongly chelate (pl. v., fig. 23).

The thoracic legs are short and stout. The first and second pairs are two-branched. The branches of the first are indistinctly two-jointed, and the outer branches are furnished with a small spine on the outer distal angle of the first joint, while the end-joint bears five moderately stout spines on its rounded extremity; the inner branches bear each two terminal spines (pl. vi., fig. 3). The second pair are rather more dilated than the first, and both branches are similarly armed (pl. vi., fig. 3).

The fourth pair is composed of a single uniarticulate branch in the form of an elongated lamelliform plate which bears a few minute teeth round the distal end (pl. v., fig. 24).

The male, which resembles the female, but is considerably smaller, being scarcely half an inch in length, and the genital segment is also proportionally shorter (pl. vi., fig. 2); there is also a difference in the second and fourth pairs of thoracic legs, as shown in the drawing (pl. vi., figs. 5 and 6). In other respects the male is very similar to the female.

Habitat.—Taken from a sturgeon, *Acipenser sturio*, captured about 16 miles S.E. by E. of Aberdeen and brought into the Aberdeen Fish Market, December 29, 1904. The same species of *Dichelestium* has also been found by my son, Andrew Scott, on the gills of a sturgeon captured near Barrow-in-Furness, Lancashire. I am indebted to Mr. Bowman of Aberdeen for this further addition to the marine copepod fauna of Scotland.

The structure of the mouth organs, and especially of the mandibles, indicates a close relationship of *Dichelestium* with the Caligidæ.

Genus *Anthosoma*, Leach (1816).

Anthosoma crassum (Abilgaard). Pl. v., figs. 15 and 16.

1794. *Caligus crassus*, Abgd., Mém. de Copenhagen, Act. Soc. Nat. Havn.

1837. *Anthosoma Smithi*, Krøyer, Naturh. Tidsskr., 1st B., p. 295, Tab. ii., figs. 2 and 2a (♀).

1850. *Anthosoma Smithi*, Baird, Brit. Entom., p. 296, pl. xxxiii., fig. 9.

1861. *Anthosoma crassum*, Steenstrup and Lütken, Bidrag til Kundskab, p. 397, pl. xxii., fig. 24 (♂).

This interesting species was found on a shark, supposed to be a Porbeagle shark, *Lamna cornubica*, captured off the coast of Scotland by one of the trawling steamers that make only short runs from Aberdeen. The steamer, which captured the shark in October 1904, is one of those belonging to Mr. Davidson, Aberdeen, and is locally known as a "short tripper." Two specimens of the *Anthosoma* were obtained; one of them is a female with ovisacs, the other, which is smaller, is probably a male. The drawings, figures 15 and 16 on plate v., represent a dorsal and ventral view of the female. This specimen measured about 15 millimetres exclusive of the ovisacs, and about 62 millimetres—nearly $2\frac{1}{2}$ inches—to the extremity of these appendages.

The female, which is tolerably elongated, appears, when seen from above to be of an ovate outline; it is narrow in front, and a brownish horny shield, which gradually expands towards the posterior end, covers the head and a considerable portion of the thorax; an obscure constriction marks the junction of the head with the thorax; two large foliaceous elytraform, circular plates, the inner margins of which partly overlap each other on the dorsal aspect, cover entirely the remaining portion of the thorax not covered by the dorsal shield, and also the abdomen and furcal joints. These plates are ornamented by numerous minute scattered punctures or depressions, as shown in the drawing (fig. 15).

The antennules are short, slender, and composed of six joints which are very sparingly setiferous; but the antennæ—described by Baird as the first pair of footjaws—are strong and powerful; they are longer than the antennules and composed of three joints, and armed with strong, terminal, hook-like claws.

The first maxillipeds are slender and feeble, and appear to consist of three joints; they are provided with a small, terminal, claw-like spine.

The second maxillipeds are short, very stout and powerfully clawed.

The thoracic legs are in the form of thin and broadly foliaceous plate, each having a distinct notch on the inner margin.

The abdomen is short and the furcal joints narrow and moderately elongated, as in figure 16, which shows the ventral aspect of the specimen.

The shield is of a chitinous texture, of a brownish colour on the sides,

but merging into blackish brown along the middle and towards the proximal end; the elytraform plates and thoracic feet, which also appear to be chitinous, are whitish with a slight tinge of yellow.

I am indebted to Mr. Irvine for the opportunity of examining and describing this interesting species.

Drs. Steenstrup and Lütken in the work referred to above give a series of excellent figures illustrative of the structure of the male of *Anthosoma*, and it would appear from the description and figures of these authors that the large foliaceous and elytraform dorsal plates which cover the posterior part of the female are absent in the male.

FAM. LERNÆIDÆ.

Genus *Pennella*, Oken.

Pennella filosa (Linne).

1754. *Pennatula filosa*, Linn., Syst. Nat. et. Amœn. Acad., vol. iv.

1767. *Pennatula filosa*, Linn., Syst. Naturæ, Ed. 12, vol. ii., pp. 13-22.

1870. *Pennella Orthagorisci*, E. P. Wright, Ann. and Mag., Nat. Hist. (4), vol. v., p. 42, pl. 1.

The Rev. Canon A. M. Norman, to whom I am often indebted for information and help in Natural History research, has, with his usual kindness, permitted me to examine a specimen of this curious copepod parasite which he received many years ago from the late Thomas Edward of Banff, who found it on a short sunfish, *Orthogoriscus mola*, in the Moray Firth. The species is recorded in Smiles' Life of Edward, among the many other Natural History rarities mentioned at the end of that work, under the name of *Pennella fibrosa*. Linnæus in his 12th Edition of Systema Naturæ, referring to the host of *Pennella filosa*, says, "Habitat in M. Mediterranei Xiphiis."

Genus *Lernæa*, Linné (1767).

Lernæa lusci, Bassett-Smith. Pl. vi., fig. 18.

1896. *Lernæa lusci*, Bassett-Smith, Ann. and Mag. Nat. Hist. (6), vol. xviii., p. 13, pl. iv., fig. 6.

1904. *Lernæa lusci*, T. Scott, 22nd F.B. Rept., Pt. III., p. 277. pl. xvii., fig. 12 and 13.

A *Lernæa* apparently belonging to this species was found adhering to a small *Gadus luscus* sent to the Laboratory from the fish market at Aberdeen on January 12, 1905. The various species belonging to the genus *Lernæa* fix themselves to the gills or gill-arches of the fishes infested by them, but the specimen now recorded had its head buried in the flesh of the fish some distance behind the operculum, as shown in the drawing (fig. 18). This is the first example of the kind I have met with.

FAM. CHONDRACANTHIDÆ.

Genus *Sphyrion*, Cuvier (1830).

Sphyrion lumpi, Krøyer.

1863. *Lesteira lumpi*, Kr., Bidrag til Kundskab, Nat. Tidskr., BR. 2 B., p. 325, Tab. xviii., fig. 5, a-g.

Sphyrion lumpi, T. Scott, 19th F.B. Rept., Pt. III., p. 128, vol. vii., fig. 13.

A fine specimen, the most perfect I have seen of this curious species, was presented to me by Mr. Irvine of Aberdeen; it was obtained by him on one of a number of catfishes, *Anarrhicas lupus*, landed at Aberdeen Fish Market from a Norwegian trawler. The fishes were captured in about 200 fathoms, and therefore beyond the limits of the Scottish area. An imperfect specimen was taken from a Lumpsucker captured in April 1900 in the nets of the salmon fishers near the Laboratory at Bay of Nigg, Aberdeen, and is described and figured in Part III. of the Nineteenth Annual Report of the Fishery Board for Scotland.

Genus *Chondracanthus*, De la Roche (1811).

Chondracanthus depressus, sp. n. Pl. vi., figs. 7–13.

Description of the Female.—This species resembles in its general appearance the *Chondracanthus fluræ* of the Long Rough Dab, *Drepanopsetta platessoides*, but it is more depressed. The cephalon, which is sub-quadrangular, is scarcely as long as broad, the next two segments are also wide and very short, while the last thoracic segment is distinctly constricted in the middle and very depressed; it is broader in proportion to its length than the same segment in *Chondracanthus fluræ*, being about as broad as it is long. The postero-lateral processes are somewhat narrow, cylindrical, and sigmoid, and curved inward so as to approach close to each other, and sometimes overlap (fig. 8). The abdomen is very short.

The specimen represented by the drawing (fig. 7) measures about 5 mm. ($\frac{1}{4}$ of an inch), exclusive of the ovisacs, which are tolerably short and thick.

The antennules are short and very robust; they are simple in structure; and the distal extremity, which appears to be obscurely jointed, bears scattered apical spinules (fig. 9).

The antennæ are somewhat similar to those of *Chondracanthus cornutus*.

The mandibles, which are stout, moderately elongated, and strongly curved, taper gradually to the attenuated distal extremity; they are each armed with a row of small but moderately stout denticles along each margin, as shown in the drawing (fig. 10).

The first maxillipeds are greatly dilated at the base, and the terminal joint, which is also stout, tapers to a blunted apex, the internal margin is coarsely toothed on the distal half (fig. 11).

Thoracic feet two pairs, short, stout, and bifid, or with two rudimentary branches; both branches are stout, but the outer is shorter and scarcely so much dilated as the inner. Though the first pair are as robust as the second they are scarcely so long; the two branches in both pairs are covered more or less with minute prickles, as shown in the drawings (figs. 12 and 13).

Habitat.—On the gills of the Flounder, *Pleuronectes flesus*, captured in the Firth of Forth and St. Andrews Bay.

This form differs from any of the species previously described by the very short anterior thoracic segments and by the last segment being depressed and of a broadly quadriform outline, as well as by the structure of the thoracic legs.

A form which appears to be a variety of the species just described, and which has also been observed on the same kind of fish, differs in being rather more elongated and less depressed. The antennules are larger, with a slightly different armature; the two pairs of thoracic legs are also larger and more robust, and the inner branches more distinctly triangular

in outline. Only one or two specimens of this form have yet been observed, and as it resembles *Chondracanthus depressus* in some respects I record it for the present as variety *oblongus* of that species (see figs. 14-17, pl. vi.).

FAM. LERNÆOPODIDÆ.

Genus *Brachiella*, Cuvier (1817).

Brachiella triglæ, Claus.

1901. *Brachiella triglæ*, T. Scott, 19th F.B. Rept., Pt. III., p. 133, pl. vii., figs. 24-29.

Habitat.—Obtained on the gills of a Streaked Gurnard, *Trigla lineata*, captured at Station VIII., Firth of Forth, in September, 1897, but only now recorded. The Forth is a new station for this species.

PART II.

ON SOME SPECIES OF TREMATODA NOT PREVIOUSLY RECORDED.

The ecto-parasitic vermes of fishes are not uncommon, but as many of them, and especially of the Trematoda, are of small size and more or less flattened, and as their colour approximates closely to that of the fishes on which they live, they are readily missed when the fishes are being examined.

There is evidently a considerable variety of forms among these Trematodes. That some of them are elegant in outline as well as in structure is shown by the beautiful drawings in MM. van Beneden and Hesse's work, *Recherches sur les Trématodes Marins*.

In the following notes I record a few curious forms exhibiting some peculiarities of structure which differ somewhat from those described in previous papers on these organisms, published in Part III. of the Annual Reports of the Fishery Board for Scotland for 1895, 1901, 1902, and 1904. I also give at the end of the present paper a list of all the species recorded in these various Reports.

TREMATODA.

FAM. POLYSTOMATIDÆ.

Genus *Phyllocotyle*, van Benden and Hesse (1863).

Phyllocotyle gurnardi, van Beneden and Hesse. Pl. vi., figs. 19 and 20.

1863 *Phyllocotyle gurnardi*, v. Ben. and Hesse, Rech. sur les Trém., p. 103, pl. x., fig. 1-7 (not *Phyllocotyle gurnardi*, T. Scott in Part III. of the 19th Report, p. 147, pl. viii., fig. 23).

Under this name I record a species of Trematode found on the gills of specimens of the Grey Gurnard (*Trigla gurnardus*, Lin.) from the Moray Firth.

The body of this Trematode is lanceolate, very flat, and moderately slender at the anterior end, but becomes wider posteriorly; the distal end is rounded, and furnished on the ventral aspect with six marginal suckers of moderate size and of a rather complicated structure—three on each margin; an elongated process, slender and narrow, and with

parallel sides, springs from the rounded end ; this process is armed at the extremity with four hooked teeth, the two outer teeth are large and strong, with an expanded base, but the other two are smaller and more slender (fig. 20).

According to the authors of the *Recherches*, this species when extended measures about 5 mm., but in the specimen represented by the drawing (pl. vi., fig. 19, of this paper), the body is considerably contracted in length, and is consequently wider, the peduncle at the posterior end, which when fully extended is very slender and narrow, is also shortened in the specimen figured. This peduncle is very fragile, and is therefore occasionally incomplete, and for that reason, and also because it can be folded back under the body of the animal, it may at times easily escape being noticed.

Genus *Plectanocotyle*, Diesing.

Plectanocotyle Lorenzii, Monticelli.

1899. *Plectanocotyle Lorenzii*, Monticelli, Di una nova Specie del genere *Plectanocotyle* ; Atti. R. Acad. delli Sci. di Torino, vol. xxxiv., p. 1, pl. 1 (separate copy).

1901. *Phyllocotyle gurnardi*, T. Scott, 19th F.B. Rept., Pt. III., p. 147, pl. viii, fig. 23.

A Trematode recorded by me under the name of *Phyllocotyle gurnardi* in the Nineteenth Annual Report of the Fishery Board for Scotland (1901), was afterwards recognised as belonging to a species described by Dr. F. R. Sav. Monticelli two years previously under the name mentioned above.

This *Plectanocotyle* had been obtained by Dr. Lorenz some years before on a species of Gurnard, *Trigla* sp. The slender posterior peduncle, so characteristic of *Phyllocotyle gurnardi*, is apparently absent in *Plectanocotyle*. The Scottish specimens from *Trigla gurnardus* were examined by Dr. F. R. Sav. Monticelli, and recognised by him as belonging to the species he had described in 1899.

As already pointed out, the peduncle in *Phyllocotyle*, being so slender and fragile, is easily damaged, and when it gets torn off or folded under the body, and when the body is shortened by contraction—a contingency not uncommon when fishes infested by the parasites are preserved in spirit or formaldehyde—the one Trematode may easily be mistaken for the other.

Genus *Microcotyle*, van Beneden and Hesse (1863).

Microcotyle donavani, van Beneden and Hesse. Pl. vi., fig. 21.

1863. *Microcotyle donavani*, v. Ben. and Hesse, *Recherches*, p. 114, pl. xii., figs. 1–11.

This species was found on the gills of a Ballan Wrasse (*Labrus bergylta*, Ascan.), obtained by Dr. H. C. Williamson in the Moray Firth on October 23, 1904, and also on a Ballan Wrasse captured in the North Sea by Mr. Bowman.

The species is narrow and elongated, and at the posterior end there is a row of small suckers along each margin ; the number of suckers in each row appears to vary to a small extent. In the specimen represented by the drawing (fig. 21) the number in each row is about thirty-four.

Microcotyle donavani does not appear to be a rare form ; the authors of the *Recherches* state that it has been found in abundance on the

same species of *Labrus* in the month of March. Several specimens were found on the gills of the *Labrus* from the Moray Firth and from the North Sea, but none were very perfect. This species of *Microcotyle* is not only very slender, but is also without consistence, and therefore easily injured. The length of the specimen represented by the drawing is 5.3mm. Figure 22 is a front view of one of the suckers seen under a moderately high magnification.

Microcotyle labracis, van Beneden and Hesse. Pl. vi., fig. 21.

1863. *Microcotyle labracis*, v. Ben. and Hesse, Recherches, p. 112, pl. xii., figs. 12-18.

This species has a general resemblance to *M. donavani*, but differs in possessing about double the number of suckers at the posterior end (fig. 21). The structure of the œsophagian bulb also differs in the two species.

The length of the specimen represented by the drawing is about 7mm.

Habitat.—On the gills of the Bass, *Labrax lupus*. I am indebted to my son for specimens of this species.

FAM. GYRODACTYLIDÆ.

Genus *Diplectanum*, Diesing (1858).

Diplectanum æquans, Diesing. Pl. vi., fig. 24.

1858. *Diplectanum æquans*, Diesing, Revis. der Myzhelm., p. 77.

1863. *Diplectanum æquans*, v. Ben. and Hesse, Recherches, p. 122, pl. xiii., figs. 9-22.

This Trematode is common on the gills of the Bass, *Labrax lupus*, but being very small it is easily missed. The length of the specimen represented by the drawing (fig. 24) is about 2mm.

In *Diplectanum æquans* the head is armed with two moderately strong hooked spines on each side of a deeply concave cleft; this cleft is occupied by a process thickly covered with minute prickles, as shown in the drawing.

I am indebted to my son for this small but interesting species.

The following is a list of species belonging to the Trematoda that have been described or recorded, and for the most part figured, in Part III. of the Annual Reports of the Fishery Board for Scotland. The species now recorded are included in the list. The names are arranged in alphabetical order.

Name of the Species.	Annual Report where published, and Number of Plate where figured.
<i>Acanthocotyle monticellii</i> , T. Scott, -	20th Report; Pl. xiii.; 1902.
<i>Anthocotyle merluccii</i> , v. Ben. and Hesse, -	19th „ Pl. viii.; 1901.
<i>Callocotyle krøyeri</i> , Diesing, - -	„ „ „ „
<i>Dactycotyle pollachii</i> , v. Ben. and Hesse, -	„ „ „ „
<i>Diplectanum æquans</i> , Diesing, - -	Present Report; Pl. vi.
<i>Epidella hippoglossi</i> , O. F. Müller, -	19th Report; no figure.
<i>Heterocotyle pastinacæ</i> , T. Scott, - -	22nd „ Pl. xvii.; 1904.

Name of the Species.	Annual Report where published, and Number of Plate where figured.
<i>Microcotyle donavani</i> , v. Ben. and Hesse,	Present Report ; Pl. vi.
„ <i>labracis</i> , „ „	„ „ „ „
<i>Octobothrium alosæ</i> (Hermann), - -	19th Report ; Pl. viii. ; 1901.
„ <i>esmarkii</i> , T. Scott, - -	„ „ „ „
„ <i>harengi</i> , v. Ben. and Hesse,	„ „ No figure.
„ <i>scombri</i> , Kuhn, - -	„ „ Pl. viii. ; 1901.
„ <i>merlangi</i> , Kuhn, - -	13th „ Pl. iv. ; 1895.
<i>Onchocotyle appendiculata</i> , Kuhn, -	19th „ Pl. viii. ; 1901.
<i>Phyllocotyle gurnardi</i> , v. Ben. and Hesse,	Present Report ; Pl. vi.
<i>Phyllonella soleæ</i> , „ „	19th Report ; Pl. viii. ; 1901.
* <i>Plectanocotyle lorenzi</i> , Monticelli, -	„ „ „ „
<i>Pterocotyle morrhuæ</i> , v. Ben. and Hesse,	„ „ „ „
„ <i>palmata</i> , Leuckart, - -	„ „ „ „
<i>Thaumatocotyle concinna</i> , T. Scott, -	22nd „ Pl. xvii. ; 1904.
<i>Tristoma mole</i> , Blanchard - -	19th „ Pl. viii ; 1901.
<i>Trochopus lineatus</i> , T. Scott, - -	„ „ „ „
<i>Udonella caligarum</i> , Johnston, - -	„ „ „ „

* Described in 1901 as *Phyllocotyle gurnardi*.

DESCRIPTION OF THE PLATES.

PLATE V.

<i>Caligus abbreviatus</i> , Kröyer.							Diam.
Fig. 1.	Female, dorsal view	.	.	.	.	.	× 14.
Fig. 2.	Female, young	.	.	.	.	.	× 27.
Fig. 3.	Antennule	.	.	.	.	.	× 72.
Fig. 4.	Sternal fork	.	.	.	.	.	× 120.
Fig. 5.	Second maxilliped	.	.	.	.	.	× 45.
Fig. 6.	Foot of fourth pair	.	.	.	.	.	× 108.
<i>Lepeophtheirus sturionis</i> , Kröyer.							
Fig. 7.	Female, dorsal view	.	.	.	.	.	× 6·6.
Fig. 8.	Antennule	.	.	.	.	.	× 72.
Fig. 9.	Antenna	.	.	.	.	.	× 45.
Fig. 10.	One of the “palpi”	.	.	.	.	.	× 67·5.
Fig. 11.	Second maxilliped	.	.	.	.	.	× 45.
Fig. 12.	Sternal fork	.	.	.	.	.	× 90.
Fig. 13.	Foot of fourth pair	.	.	.	.	.	× 28.
Fig. 14.	Last segment of abdomen and furcal joints	.	.	.	.	.	× 31.
<i>Anthosoma crassum</i> , Abgld.							
Fig. 15.	Female, dorsal view	× 6.
Fig. 16.	Female, ventral view	× 6.



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Dichelestium sturionis, Hermann.

Fig. 17.	Antennule, female	x	46.
Fig. 18.	Antenna, female	x	17.
Fig. 19.	Antenna, male	.	.	.	.	.	.	x	17.
Fig. 20.	Mandible	.	.	.	.	.	.	x	60.
Fig. 21.	Maxilla	.	.	.	.	.	.	x	46.
Fig. 22.	First maxilliped, female	.	.	.	.	.	.	x	23.
Fig. 23.	Second maxilliped, female	.	.	.	.	.	.	x	15.
Fig. 24.	Foot of fourth pair, female	.	.	.	.	.	.	x	28.

PLATE VI.

Dichelestium sturionis, Herm.

Fig. 1.	Female, dorsal view	.	.	.	.	.	.	x	4·6.
Fig. 2.	Male, dorsal view	.	.	.	.	.	.	x	4·6.
Fig. 3.	Foot of first pair, female	.	.	.	.	.	.	x	46.
Fig. 4.	Foot of second pair, female	.	.	.	.	.	.	x	46.
Fig. 5.	Foot of second pair, male	.	.	.	.	.	.	x	46.
Fig. 6.	Foot of fourth pair, male	.	.	.	.	.	.	x	24.

Chondracanthus depressus, sp. n.

									Diam.
Fig. 7.	Female, dorsal view	.	.	.	.	.	.	x	12.
Fig. 8.	Posterior appendages of same	.	.	.	.	.	.	.	enlarged.
Fig. 9.	Antennule	.	.	.	.	.	.	x	60.
Fig. 10.	Mandible	.	.	.	.	.	.	x	260.
Fig. 11.	First maxilliped	.	.	.	.	.	.	x	260.
Fig. 12.	Foot of first pair	.	.	.	.	.	.	x	55.
Fig. 13.	Foot of second pair	.	.	.	.	.	.	x	55.

Chondracanthus depressus, var. *oblongus*.

Fig. 14.	Female, dorsal view	.	.	.	.	.	.	x	12.
Fig. 15.	Antennule	.	.	.	.	.	.	x	60.
Fig. 16.	Foot of first pair	.	.	.	.	.	.	x	55.
Fig. 17.	Foot of second pair	.	.	.	.	.	.	x	55.

Lernæ lusci, Bassett-Smith.

Fig. 18.	Gadus lucus with parasite <i>in situ</i>	reduced.
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Trematoda.

Fig. 19.	<i>Phyllocotyle gurnardi</i> , v. Ben. and Hesse	x	45.
Fig. 20.	Extremity of peduncle of the same	x	260.
Fig. 21.	<i>Microcotyle donavani</i> , v. Ben. and Hesse	.	.	.	.	.	.	x	27.
Fig. 22.	The same—one of the posterior suckers	.	.	.	.	.	.	x	390.
Fig. 23.	<i>Microcotyle labracis</i> , v. Ben. and Hesse	.	.	.	.	.	.	x	18.
Fig. 24.	<i>Diplectanum æquans</i> , Diesing	.	.	.	.	.	.	x	45.

IV.—REPORT ON THE OPERATIONS AT THE MARINE HATCHERY, BAY OF NIGG, ABERDEEN, IN 1904. By Dr. T. WEMYSS FULTON, F.R.S.E., Superintendent of Scientific Investigations.

During the season of 1904 the operations at the Marine Hatchery were continued in connection with the hatching of the eggs of the plaice, as in previous years, and a number of lobsters were also dealt with. The hatching apparatus and the various ponds in connection with the establishment continue to perform the work for which they were intended in a satisfactory manner. An account of these and of the methods employed in the collection of the eggs and their treatment in the hatchery has been given in some of the previous reports, to which reference may be made for the detailed description.

It need only be said here that the adult fishes which act as the brood stock are confined throughout the year in a large tidal pond, where they are regularly fed, almost entirely with common mussels, and that at the spawning-time the fertilised eggs, shed freely into the water, are collected daily, or almost daily, by means of a large net of mosquito netting, and are then transferred to the incubating apparatus in the hatchery.

The duration of the period of development, until hatching takes place, varies according to the temperature of the water at the time; the period is longer at the beginning of the spawning season, when the temperature is low, than towards the end of the season, when the temperature has risen considerably. At the beginning of the work in January the average time of incubation before the eggs hatch is about three weeks, while at the end of the season they hatch in about a fortnight. The larval fishes, after they are hatched from the eggs, are kept in the apparatus for several days until the yolk-sac is partly absorbed, and they are then transferred to the sea in appropriate apparatus. Experience has shown that the best results are got by liberating the fry before the yolk has been quite used up, and when they are able to feed for themselves.

It is calculated that, taking the two periods together—the time of incubation and the period referred to after hatching—the eggs and larvæ are protected in the apparatus for about half of the time from the spawning of the eggs to the transformation of the post-larval fish, *i.e.* to the adoption of the adult form and habit, after which, owing to the protection afforded by concealment in the sand, the natural mortality is, relatively speaking, small.

In the season of 1904 the floating eggs were first observed in the water of the spawning pond about the middle of January, but they were few in numbers. The first collection was made on the 26th of that month, about the same date, that is, as in the preceding year. The last collection was made on the 29th April, or more than a fortnight earlier than in 1903. This is probably partly accounted for by the greater relative intensity of the spawning in the earlier part of the season in 1904, but it is also, no doubt, connected with the fact that

the number of the adult fishes furnishing eggs, and therefore of the eggs collected, was considerably under what it was in 1903. As pointed out in previous reports, a certain number of the plaice confined in the pond die each year, and this loss is ordinarily made up by a renewed supply of living adult fishes in the autumn, which are obtained from the trawlers employed for scientific purposes in Aberdeen Bay or the Moray Firth, the vessels being provided with large tubs for the collection of the fish, and a constant circulation of water maintained until port is reached. In the autumn and winter of 1903 the same practice was followed, but it was found that large adult plaice, suitable for the hatchery, were exceedingly and unusually scarce, and thus the stock in the pond was only partially replenished.

The total number of eggs collected from the spawning pond throughout the season was 39,600,000, as compared with 65,940,000 in the previous year. Most of them, as is usually the case, were obtained in March, which is the chief spawning month of the plaice. The numbers collected in the various months, and the percentages on the total number, are given in the following table, which also contains for comparison the corresponding monthly percentages for the previous season in 1903:—

		Number of Eggs Collected.	Percentage, 1904.	Percentage, 1903.
January,	-	660,000	1·6	0·3
February,	-	10,320,000	26·1	18·0
March, -	-	22,040,000	55·7	56·2
April, -	-	6,580,000	16·4	24·1
May, -	-	..	..	1·3

It will thus be seen, as above indicated, that spawning was, on the whole, a little earlier in 1904 than in 1903, nearly 28 per cent. of the aggregate number of eggs being collected before March in the former year, as compared with 18 per cent. in the same period in the latter year.

The estimated number of fry which were obtained from the eggs amounted to 34,780,000, and they were liberated in seven lots at various dates in March, April, and May, off Aberdeen Bay, a fishing yawl being employed for the purpose.

Particulars as to the collection of eggs from the pond and the liberation of the fry will be found in the tables which are appended.

The expense of the hatching operations as carried on at the Bay of Nigg is small, compared with the number of fry produced. This is owing to the fact that the hatchery is worked in conjunction with the Marine Laboratory, for which pumping operations are required throughout the year. The annual expenditure that may be ascribed to the hatching work is about £100, the principal items being the maintenance of the apparatus, food for the fishes, and extra coals.

The hatchery was visited by delegations of fishermen sent for instruction by the County Councils of Aberdeenshire and Argyllshire, to whom a series of demonstrations was given.

TABLE I.—Showing the Daily Progress of the Hatching Operations,
and the Temperature of the Water, during the Hatching
Season 1904.

TABLE I.—*continued.*

TABLE II.—Showing particulars in connection with the
Distribution of Fry.

Date.	Locality.	Temp. of the Water.	Condition of Weather.	Estimated Number of Fry.
March 15	About 1½ miles off Aberdeen Bay.	C. 5·2	Fine.	4,000,000
„ 25	„ 2½ „ „ „	5·0	„	5,000,000
April 1	„ 1½ „ „ „	...	„	4,000,000
„ 8	„ 2 „ „ „	5·6	„	4,280,000
„ 16	„ 1½ „ „ „	6·0	„	6,000,000
„ 26	„ 2½ „ „ „	...	„	7,000,000
May 7	„ 1½ „ „ „	...	„	4,500,000
				34,780,000

V.—ZONES OF GROWTH IN THE SKELETAL STRUCTURES OF GADIDÆ AND PLEURONECTIDÆ. By J. T. CUNNINGHAM, M.A., F.Z.S. (Plates VII-IX.)

PREVIOUS INVESTIGATIONS.

The primary object of Reibisch's investigations was to ascertain what relations existed between the number of eggs produced by a plaice and its size or age, whether if the number of eggs varied, it depended on the size or on the age of the fish or on both. In describing his method of enumerating the eggs to be shed in the following spawning season, Reibisch shows that he was not acquainted with my own paper on the development of the ovarian egg in Teleostei in general and Pleuronectidæ in particular published in the *Quarterly Journal of Microscopical Science* in 1897. For he explains the opacity of the larger eggs in the ovary in August as due to oil-drops—"durch die Aufnahme einer grossen Zahl kleiner fett tröpfchen zu erklären"—whereas I have shown that in *Pleuronectes* ova there are no oil-drops, but only yolk granules, while in the developing eggs of sole, mackerel, &c., both yolk granules and oil-drops are present and are easily distinguished from one another.

Reibisch found great variations in the number of ripening eggs in plaice, and these numbers could not be brought into correspondence with either the weight or the length of the fish. He then found that the various numbers formed three principal groups, between which few or no numbers were found: thus there were large numbers of fish with eggs from 50,000 to 170,000, or from 220,000 to 270,000, but scarcely any fish whose number of eggs lay between 170,000 and 220,000. It seemed therefore probable that the groups of numbers corresponded to different ages, and Reibisch sought for a method of ascertaining the age of the fish.

He rejects entirely the markings of the scales as indications of the age in the plaice, stating that the lamination of the scale can be used for the purpose in view in the carp, but that this is impossible in the case of the plaice. The reasons he gives are that the presence of an annual lamination (Jahresschichtung) is scarcely to be demonstrated in the simple cycloid scales of the plaice, and further, that in almost all regions of the latter there occurs a transformation of the cycloid to the ctenoid form. But he seems to have misunderstood Hoffbauer's work on the carp, for that author deduces the age, not from the lamellæ, if such exist, but from the varying distance between the concentric lines of the scale, and these also occur in the scales of plaice. I have shown by my observations, described below, that the distinction of the growth of successive years in the scales of the plaice, from the different intervals between the concentric lines, is not impossible. The remarks of Reibisch concerning the transformation of the scales into the ctenoid form in the plaice refers to the Baltic variety on which he worked, in which spinules on the scales are strongly developed, especially in adult males. But this does not affect the anterior embedded part of the scale, and I have not noticed spinules on the scales I have examined. The spinules are developed in adult males in the North Sea, but they are usually confined to limited portions of the

skin, and I have not met with spinulated scales hitherto among those I have examined for indications of age.

Reibisch therefore turned his attention, at Hensen's suggestion, to the otoliths. He describes the appearance of these structures as seen by transmitted light. He states that the first year's deposit consists of a very dark, *i.e.* opaque, nucleus or kernel; this is surrounded by a narrow transparent ring, then follows a broad dark zone, which is again surrounded by a light zone, and this again is bounded by a dark contour. He states that the nucleus and the first clear ring with part of the dark zone are formed during pelagic life, the outer clear zone during the sojourn in shallow water near the coast, while the dark contour is formed only when the fish has migrated into deeper water, about January or February. It will be seen that my results agree closely with those of Reibisch, except in the last point, for I have not noticed that the dark zone of the second year had begun to appear in specimens collected in March and April, and it seems to me that it is formed in summer. Reibisch figures the otolith of a specimen 11.5cm. long taken at the end of February, in which he believes the deposit of the second year had begun and was visible at the anterior and lower side of the otolith. He figures also an otolith from a specimen 16.5cm. long taken at the end of February which similarly shows the beginning of the third year's deposit, and another from a specimen 23.5cm. which shows three complete years and the beginning of the fourth. This specimen was a ripe male taken on the 9th March, and the deposit of the fourth year in the figure is almost as wide in some parts as that of the third. It seems to me difficult to believe that this could have been formed in a few weeks, and more probable that it represents the whole deposit of the previous year, so that the specimen was four years old. It is in cases of this kind that the difficulties of the method arise, and they can only be settled by ascertaining with certainty at what time of the year the boundary line between the annual zones is formed. Reibisch assumes that the new opaque deposit begins in January or February, while my own opinion at present is that it does not commence till much later.

Reibisch concludes from his investigations that sexual maturity occurs always at the end of the third year, and that the reason why the fish are so different in size and weight at this period of life is that they were hatched at different periods of the same season. In my experiments on the rearing of flounders in captivity at Plymouth I also found that the majority began to spawn at the end of their third year, but a few were ripe at two years of age.

Reibisch concludes that the darker layers in the deposit of one year in the otolith corresponds to the lower temperature of the water in which the plaice lives, and the more transparent layers to the warmer temperature. He also states that the excretion of carbonate of lime is weaker in the first half of the year, when the temperature is low. According to his reasoning therefore, the more opaque layers are those in which the proportion of carbonate of lime is least, and these are formed at the time when the lower temperature of the surface penetrates to the deeper water, which is usually from January to March. The annual period indicated by a complete zone in the otolith would, on this view, coincide with the calendar year and commence in January.

My conclusions, from my own observations so far as they have gone, are not in harmony with those of Reibisch on the above points. In the first place, it seems to me probable that the opacity would increase, not diminish, in proportion to the amount of carbonate of lime present: this is certainly the case in bone and calcified cartilage, and it is also the case in the scales, where the radiating and concentric lines *between* the sclerites

are very transparent. Secondly, I have not found that the external layers in the otoliths of plaice killed between November and April were dark opaque layers, but, on the contrary, in otoliths at this period the peripheral layers were of the more transparent kind. Thirdly, the conclusions of Reibisch seem to me to be in contradiction to the facts concerning the first or central region of the otolith, and Reibisch excludes the deposit of the first year from consideration on the ground that during this year the young fish are exposed to very varying conditions of whose influence on the organism we know next to nothing. I fail to see the force of this remark ; it seems to me we have as much ground for reasoning about the first year as about any other. Now, though the eggs are produced early in the year, when the water is cold, the young plaice do not complete their metamorphosis until May or June. The first specimens which I received this year from Dr. Fulton were caught at four to eight fathoms on May 10. In these the only part of the otolith formed was the central kernel, and apparently not the whole of that. Therefore, it is evident that the opaque portion of the first year's zone, outside the nucleus, is formed in summer, not in winter, in warm water, not in cold ; and the condition of the otolith with only the first year's zone, from fish caught in February or March, equally proves that the more transparent zone is formed in winter, not in summer.

This interpretation might seriously affect the conclusions of Reibisch concerning the age of the fish which he examined, as it seems probable that he has interpreted, in some cases, as the commencement of the fourth year's deposit, a zone which in reality represents a whole year of age. Thus fish which he has taken to be three years old might in reality have lived four years.

Jenkins investigated the determination of age from the otoliths in herring and other Clupeidæ. He finds that in the herring there are layers in the otolith as in the plaice, but with some differences. The central nucleus is always transparent, not opaque ; the opaque zones are much broader in proportion than in the plaice, and separated by very narrow transparent zones, which, according to Jenkins, are formed at the beginning of the new year. It would seem more probable that, as in the plaice, these form the end of the year's deposit. Jenkins' paper is illustrated by photographs of the object, in which the different zones are not always very distinct. The structure could, I believe, have been shown more satisfactorily by drawings. Jenkins finds that the herring of the Western Baltic have the following lengths at successive years of age :—

1st year,	.	.	.	.	.	11·3–12·1cm.
2nd „	.	.	.	.	.	15·6–16·4cm.
3rd „	.	.	.	.	.	19·0–19·8cm.
4th „	.	.	.	.	.	21·7–22·5cm.
5th „	.	.	.	.	.	23·7–24·5cm.

Jenkins rejects the conclusion held by nearly all naturalists who have investigated the herring, that two season-races can be distinguished, on the ground that ripe or nearly ripe or spent herrings can be found in the Western Baltic at all times of the year.

He has misunderstood a statement which he quotes from myself, that two spawning periods have undoubtedly been observed in the same neighbourhood, stating that it is in contradiction to Heincke's assertion that herring spawn is never found twice in the year on the same spot. There is really no contradiction. Anyone acquainted with the subject knows that spring or winter spawning herring and summer or autumn spawning herring are captured by fishermen in large numbers in the same

district, for instance, in the Western Baltic, where Jenkins studied, but I have never stated that they use the same spawning grounds.

Jenkins finds that the herring becomes sexually mature in its third year.

2. GENERAL DESCRIPTION OF LINES OF GROWTH.

One of the chief objects of my observations was to test the question how far the lines of growth in the skeletal structures of fishes were trustworthy indications of age, whether the annual increments of growth or deposit could be definitely distinguished and counted in all cases. The most direct and satisfactory basis for the assumption that the age of individual fishes can be ascertained by inspection of lines of growth in certain structures would be an extensive study of such lines in fish whose age was known by direct evidence, but hitherto such study has not been possible to any great extent. All I have been able to do is to ascertain the age of specimens of different sizes as indicated by the lines and zones of growth, and to compare the conclusions so reached with those to be derived from other sources, such as the season in which the specimens were collected, their size, and the evidence available concerning the rate of growth from experiments with fish reared in captivity.

Another object which was in view in the investigation was that of discovering, as far as possible, the mode in which the lines of growth were produced, what differences of structure caused the lines, and what was the relation between the seasonal changes in external conditions and the processes of growth taking place in the structures concerned.

In the plaice successive more or less parallel lines and zones are visible in the otoliths, in the scales, in the coracoid element of the pectoral girdle, which consists of calcified cartilage, and the surfaces of the vertebral centra bounding the conical depressions in their anterior and posterior faces.

The otoliths consist of a number of thin layers deposited one over the other around a common centre. The structure may be described as a concentric stratification, and, apparently, when once deposited a layer undergoes no subsequent change. The otoliths are thin and flat, but one surface is more convex than the other, and this more convex surface is in the natural position within the ear-capsule directed inwards and the flat surface outwards. I find the most convenient way to extract the otoliths is to split the skull with a knife from behind forwards, the ear-capsules being then exposed, as they are not separated from the cranial cavity by bone. The otoliths have a longer and a shorter diameter, and along the direction of the longer diameter there is a groove on the central part of the convex side. They appear to be formed as concretions excreted by the epithelium lining the sacculus of the auditory vesicle.

Examined in water when freshly removed from the skull of the fish, the otolith exhibits both concentric and radiating lines, so that its structure resembles that of a scale, but the mode of formation is different, the otolith being formed externally to the epithelium of the auditory sac, which is derived originally from the epidermis (epiblast), while the scale is formed within the derma (mesoblast). At first sight it might be supposed that the successive deposits were formed only at the edge of the otolith, but by examining a transverse slice of the object cut roughly with a knife, it is seen that each successive layer extends over the whole surface, but is exceedingly thin on the two flat surfaces and thicker at the edge. The structure is such as would be produced if a sphere composed of concentric uniform layers of plastic material were very much

compressed so as to form a flat disc. The thin layers on the two faces being translucent, the surfaces of contact between successive layers are seen as lines approximately parallel to the outer edge. The layers are thin and very numerous, but they are grouped into broader zones by differences of opacity. Each zone is usually distinctly defined from that which succeeds it externally, the line of division being due to a sudden increase in opacity in the layers which form the commencement of the next zone. By transmitted light the more opaque layers appear dark, and the more transparent layers light. All my figures show the appearance of the otoliths by transmitted light, the otoliths being examined in water as transparent objects. When the light is shut off from below and the object seen by reflected light, the appearances are reversed, the opaque regions appearing white and the transparent dark. My observations agree closely with Heincke's description of the structure as seen by reflected light, but I find that examination by transmitted light shows the structure more distinctly. The central area or first zone shows minor subdivisions, but the limits of these are not so distinct as the more external boundaries, and the whole of this central area appears to be formed in the first year of life. It consists of a central very opaque nucleus, followed sometimes first by a transparent zone, then one more opaque, and then a broader more transparent. But these minor zones are not always distinct, while the limit of the whole central area is usually quite definite.

The radiating lines are due to narrow grooves on the surface terminating in notches on the edge, and seem to be formed by folds in the membrane of the auditory vesicle containing the otolith.

The scales of the plaice, like those of the cod, exhibit a number of concentric lines formed by ridges on the outer surface of the scale, but these ridges are very much finer, closer together, and less regular than in the scales of *Gadidæ*. In the anterior embedded portion of the scale the ridges are divided up into short bars by radiating bands which appear transparent by transmitted light, but in the posterior more superficial part of the scale these radiating lines are absent, and the ridges appear as continuous wavy lines. Separate sclerites cannot be distinguished as in the cod, although doubtless the ridges and the radiating lines in the one case correspond to those in the other. Successive zones can usually be distinguished in consequence of the fact that the lines or ridges are closer together in certain zones than in others. A complete zone may be considered to be the result of one year's growth. The summer's growth commences with lines or ridges which are rather far apart, and after a certain distance the lines become more closely crowded; then the next summer's growth is indicated again by lines farther apart (fig. 10, pl. viii.) The transition from the crowded lines to those further apart on the outside is somewhat sudden, so that the commencement of the new summer's growth is often fairly distinct. But in most cases the zones are somewhat difficult to distinguish, and it would be by no means easy to form a confident judgment of the age of the fish by examination of the scales alone. The conclusion drawn from the scales must be confirmed or tested by examination of the otolith.

I have not found any sufficiently distinct lines of growth in the opercular bones, as Heincke states, but such lines are visible in the elements of the pectoral girdle and in the concave faces of the vertebræ. In neither case, however, are such good indications given as in the otolith. I have represented the appearance of a vertebra and of the pectoral elements in figs. 13, 14, pl. viii. The pectoral girdle of the plaice consists of a somewhat thick ossified cleithrum, thicker and less expanded ventrally than that of the cod, and a scapula and coracoid consisting chiefly of calcified cartilage. The coracoid comprises two parts, a thin ossified ventral portion bordered by a

slender curved rod of bone, and a somewhat quadrate dorsal portion of calcified cartilage. The centre of growth is at the junction of the bony rod with the cartilaginous plate, and at intervals there are lines parallel to one another where calcification is more complete, and the cartilage consequently more opaque. The scapula shows similar lines, and they are parallel to the edges where the two elements meet. The basal elements with which the fin rays articulate are represented by a small plate of cartilage with three or four minute points of ossification.

The faces of the vertebræ show by reflected light opaque white bands separated by darker, more transparent lines, and these are probably annual increments of growth, but it is difficult to be sure of counting the complete number, as the more central ones seem always doubtful and indistinct.

In the cod the scales (fig. 15) exhibit concentric and radiating lines as in the plaice, but the radiating lines occur all round the scale, and the concentric lines are much more distinct and farther apart. Careful examination shows that the two systems of lines are due to the fact that the outer surface of the scale is made up of rings of separate elements, which may be conveniently termed sclerites. Each sclerite consists of a flat base with a projecting ridge, the ridges being placed in line with those of the neighbouring sclerites of the same ring. The ridge is situated near the outer border of the sclerite, and the edge of it is turned towards the hilum or focus of the scale, so that there is a depression or concavity on the inner side of the ridge. These sclerites are evidently the structures described by Marett Tims as scalelets in the passages quoted from his paper by J. Stuart Thompson (*Jour. Mar. Biol. Assn.*, No. 1, 1904). He states, however, that each scalelet consists of a basal plate with a minute spine projecting from its upper surface, a description which he has apparently taken from the appearance presented in transverse section, whereas the apparent spine is merely the section of a longitudinal ridge on the sclerite, as I have stated. The ridges on the sclerites are also identical with the rolls or cylinders which cover the surface of the scale, according to Ussow's description.

According to Marett Tims, the scalelets are covered with a delicate epidermis. In my sections I find cell-nuclei both on the upper and lower surface of the scale, and have no doubt that the scale is covered with cells, to whose activity its formation is due. These cells or their nuclei are particularly evident at the edges of the scale, where it increases in extent, and where the new sclerites are successively formed. Nuclei can also be seen in the concavity on the inner side of the ridge of the sclerite, which agrees with Klaatsch's statement "that the cells arrange themselves on the surface of the scale in curved rows, and form always in front of themselves the substance out of which the rolls are made." I find, however, that the new sclerites are formed only at the edge, and that the above description of the cells and "rolls" or ridges applies only to the upper surface of the scale. Fig. 17, pl. ix., shows the appearance of a transverse section of the skin of a cod under a low power. The epidermis is of considerable thickness, and consists of small cells whose boundaries are not distinct in the preparation, but whose nuclei are seen as dots. The lowest layer of nuclei are somewhat elongated in a direction vertical to the lower surface of the epidermis. Beneath this lower layer are seen large oval masses of black pigment, the sections of the chromoblasts. In the middle region of the epidermis are a number of rounded cavities. The specimen from which the preparation was made was preserved with formaline, and I am unable to state whether these cavities exist in the living skin or are the result of the action of the formaline. At the surface of the epidermis are seen two minute somewhat fusiform

bodies composed of elongated cells: these are sense-organs, which in the cod are freely distributed over the surface of the skin, in addition to the special organs of the lateral line. The derma below the epidermis consists of fine fibres having a horizontal direction, with numerous nuclei, and in this occur the scale-pockets containing sections of the scales. Of these, three layers at three different levels are seen in most sections, in consequence of the fact that the scales are imbricated, and overlap one another, so that portions of three different rows of scales are cut by one section vertical to the surface. The relations of the sclerites to the lower homogeneous portion of the scale are shown in the figure, but the cellular investment of the scale is not represented, as it is not sufficiently distinct under a low power.

The ridges on the scales are seen to be farther apart in some regions, more closely crowded in others, so that zones may be distinguished. In other words, the sclerites formed at some periods of the growth of the scale are narrower than at others, so that their ridges are closer together. There is good reason for believing that the narrower sclerites are formed in winter, when the temperature is low. In the cod I find that the end of a year's growth is usually indicated by one or two markedly narrow rings, while the gradual narrowing of the sclerites as this boundary is approached, though it can be made out, is not at first obvious. In these points my observations agree generally with the descriptions and conclusions of Mr. J. Stuart Thompson, who, however, though he studied several species of Gadidæ, did not investigate the cod. In larger and older specimens several annual zones can be distinguished, each terminated by a winter zone, between which and the summer growth there is often a distinct contrast. The distinction however, is not so obvious as in the earlier or inner zones, and it would be very difficult, from the scales alone, to form a decided conclusion as to the age of a cod.

Dr. Heincke has pointed out, in his paper in the Report of the International Investigations, shortly to be published, that lines of growth are more or less distinctly visible in various bones of fishes, while the lines and zones of the otolith have previously been investigated in the plaice and herring. In the cod I have examined the bones of the pectoral girdle, of the operculum, of the skull, and of the vertebral column.

The pectoral girdle differs from that of the plaice in several particulars. The cleithrum (the large superficial bone behind the branchial cavity, formerly known as clavicle) is thinner, and only the scapula is directly attached to the posterior and inner aspect of the cleithrum. There is a long and strong post clavicle. The cleithrum is ossified, but the scapula and coracoid consist of calcified cartilage. There is no scapular foramen. There are four distinct and partially ossified fin-supports, instead of one cartilage, as in the plaice. The form of the parts is shown in fig. 20, pl. ix. I could not satisfactorily make out annual zones in any of these structures. On the thin transparent part of the cleithrum there are sometimes visible some lines parallel to the edge, but they are very indistinct. Also in the coracoid there are slightly opaque lines parallel to the edge, but still less distinct, and no definite conclusions as to the age of the fish can be drawn from them. I am unable, therefore, to agree with Heincke, who states that the age of cod can be determined from the coracoid and scapula.

I have found the bones of the operculum and skull equally unsuitable for the purpose here in view. In the vertebral column of a specimen of some size, parallel lines are distinctly visible in almost every part and on every process, including the walls of the anterior and posterior cavities, the neural spines, and the transverse processes, but I have found it impossible to use them as satisfactory indications of age. On the walls of the conical hollows of the centra numerous concentric lines appear,

lines of greater opacity appearing white by reflected light, and these lines are arranged in bands separated from each other by bands of darker, more transparent bone. Each of these bands may indicate a year's growth, being the summer growth separated from that of the next summer by a band where there is less calcareous matter. But it is difficult to decide exactly how many such annual zones are present. Even when one or two of the outer zones seem distinct, the number of the central earlier zones cannot be distinguished with certainty. One may count three at one time, and at the next attempt there seem to be four or five, and the total number always remains doubtful and uncertain.

The otolith in cod and other Gadidæ is large and opaque, and by examining it as a whole nothing can be ascertained of its internal structure. It is therefore, according to Heincke, useless for the purpose of determination of the age of the fish. I have found, however, that the successive laminæ of which it is composed can be seen quite distinctly in transverse slices simply cut from the central region of the otolith with a scalpel. Such slices are, of course, rather thick, and their surfaces are rough and irregular. Nevertheless, when they are placed in water in a watch-glass and examined with a low-power objective, they are sufficiently transparent to show the successive laminæ of which the otolith is composed, and the laminæ in certain zones being much more opaque than in the zones between these, the whole section is distinctly divided into regions which I believe to indicate the annual increments, and which, therefore, show the age of the fish.

The otolith (*i.e.* the sagitta or largest otolith) of the cod is somewhat elliptical in outline, with rather pointed ends, and two surfaces, one convex and rather smooth, the other concave and more irregular. The convex surface is turned inwards, *i.e.* towards the brain, and somewhat downwards, the concave outwards and upwards. The convex surface is marked by a shallow longitudinal groove, into which fits the ridge of sensory epithelium, called the macula acustica of the sacculus. The edge of the otolith is divided by radial grooves into lobes which are chiefly developed on the concave surface, and the central part of the concave surface projects slightly as a convexity. Fig. 16, pl. viii., shows the appearance by transmitted light of a transverse slice as above described. There is a central opaque nucleus surrounded by successive laminæ which are thicker in the parts corresponding to the edges of the otolith than in those corresponding to the surfaces. The nucleus is nearer to the convex surface than to the concave. The nucleus is surrounded by a number of opaque laminæ, and these are succeeded by a number of more transparent ones. Then comes another zone of opaque laminæ, while the most external are again more transparent. According to my interpretation, the opaque zone represents the deposit of one summer, the transparent that of one winter, so that the two zones together represent the result of one year's growth and indicate one year of age. The fish from which the otolith figured was taken was therefore two years old.

For practical purposes, to determine the age of a number of specimens quickly, I find the best method is to examine a few scales in water, noting the number of winter zones, and the age apparently indicated, and then to extract an otolith by splitting the skull in the median plane, and to cut a transverse slice of the otolith in the manner described above. In this way the conclusions drawn from the scales can be tested and confirmed or modified. It may be asked why I have not prepared thinner and more perfect transverse sections of the otolith by grinding down thick slices. I have tried this method in the plaice, and not found it very successful. The piece to be ground down, after one surface has been ground smooth, must be fixed on a glass slide with Canada balsam in

order to grind the other surface. After the operation the section is opaque from the scratching of the surface, and if it is clarified and mounted in balsam it becomes too transparent, so that the contrast between the opaque and transparent zones is largely lost. I have not yet tried the method for transverse sections of the cod's otolith, but doubt if it would be suitable, and in any case the time required makes it useless for practical purposes.

The following are the details of my observations on specimens of Plaice, Cod, and other species:—

YOUNG PLAICE AND DAES COLLECTED BY SHRIMP-NET IN ABERDEEN BAY IN MAY 1904.

The plaice in this sample ranged from 5·5 to 8·7cm. in length, and there were very few of them. Unfortunately, they were preserved in formaline, and when I came to examine them I found that the action of this reagent had altered the otoliths so that the lines of growth could not be distinctly seen. Formaline has a decalcifying action, and although in these specimens the otoliths were not destroyed, they were rendered quite opaque and granular, so that the usual structure was scarcely visible. It seemed probable, however, that they had the characters of the central deposit of the first year, without any sharp dividing lines separating distinct zones. In this case there can be little doubt that the fish were one year old, as the new brood of the current year are still, in May, in the pelagic stage, and it is unlikely that fish so small should be more than one year old.

The scales are apparently not affected by the formaline as the otoliths are; that is to say the characteristic concentric lines are quite distinct. The posterior or embedded part of the scale consists of five radiating rows of short curved lines, not regularly parallel but irregular, separated by plain bands, while the anterior part of the scale is marked by continuous successive lines approximately parallel to the edge of the scale (fig. 1). There is no division of these series of lines into zones, and the whole may be regarded as the growth of one year.

YOUNG PLAICE FROM SOLWAY FIRTH, COLLECTED ABOUT APRIL 17, 1905.

The results of examination of the otoliths in these specimens are as follows, males and females being given separately:—

MALES, IMMATURE.

(1) 6·6cm. in length.—Only one central area visible. It contains a central opaque nucleus, the part around which is slightly more opaque than the external zone. Concentric lines of lamination faint (fig. 4).

(2) 6·9cm. in length.—Only one central area.

(3) 7·1cm. in length.—Only central area, concentric lines of lamination around the opaque nucleus.

(4) 7·1cm. in length.—Central area only as in other cases, but near the outer edge a distinct transparent band with an opaque band outside it at the extreme edge. This might possibly be the commencement of the second year's deposit.

(5) 9·8cm.—Only one zone.

(6) 9·9cm.—Two zones.

(7) 10·5cm. in length.—Two distinct zones, that is to say a distinct zone outside the central area. The central area is ·95mm. in the shorter diameter, the total transverse diameter of the otolith being 1·92mm.

(8) 10·8cm.—Two zones quite distinct.

(9) 13·2cm.—Shows three zones.

FEMALES, IMMATURE.

(1) 8·9cm. in length.—Only central area present.

(2) 9·2cm. in length.—Otolith shows two distinct zones, the external one being defined by a sharp boundary line, and commencing with several laminae of very opaque deposit (fig. 8, pl. vii.).

(3) 10·5cm. in length.—Two zones visible, the central area small and not quite so sharply defined as usual—12·0cm.

(4) 15·5cm. in length.—Two zones rather less distinct than usual, central area showing distinct lamination.

(5) 15·9cm.—Shows three distinct zones.

According to these results, therefore, males from 6·6cm. to 9·8cm. in length are one year old, and at 10·5cm., or $4\frac{1}{5}$ inches, are two years old. Females may be one year old up to 8·9cm., or very nearly 4 inches, while others from 9·2cm. to 15·5cm., or 4 to 6 inches, are two years old, and one of 15·9cm., or about $6\frac{2}{5}$ inches, is three years old.

According to Heincke, in the Report of the International Committee, vol. iii., the plaice at the Sylt are from 10cm. or less to 14cm. at one year of age, 10cm. to 19cm. at two years, and 13cm. to 28cm. at three years. These sizes are taken from specimens collected in March, and therefore comparable with those from the Solway Firth examined by me. The results therefore agree, but Heincke's observations have the defect that males and females are not distinguished in them.

SPECIMENS OF PLAICE RECEIVED FROM ABERDEEN ON MAY 8, 1905, AND CAUGHT A FEW DAYS BEFORE.

These specimens, of which 14 were carefully examined, ranged in length from 4·8cm. to 11·4cm., and only one was identified as a female. The others were either male or their sex could not be determined. They must be considered as belonging to last year's brood, as the young plaice of the current year have but just completed their metamorphosis.

(1) 4·8cm. long.—Sex not determined. One zone only in otolith, transparent ring next to the nucleus not seen. One year old.

(2) 4·8cm. long.—Sex not determined. One zone only in otolith; but there was a narrow, more transparent zone next to the nucleus, as in Reibisch's description of the first year's growth. One year old.

(3) 5cm. long.—Apparently male. One annual zone only in otolith, a broad region of somewhat opaque layers round the central nucleus, more transparent narrower zone at outer edge, that is the transparent region next to the nucleus as described by Reibisch, was not visible. Concentric single layers distinct in the middle zone.

(4) 5·7cm., probably male.—One zone in otolith.

(5) 5·7cm., probably male.—One zone in otolith.

(6) 6·7cm., female.—One zone only.

(7) 7·2cm., probably male.—One zone only.

(8-10).—Three specimens, 8·5cm. long, apparently male, all showing one zone only.

(11) 9·6cm., male.—One zone only.

(12) 9·8cm., male.—One zone only.

(13) 10·3cm., male.—One zone only.

(14) 11·4cm., male.—One zone only.

PLAICE RECEIVED FROM ABERDEEN, APRIL 1, 1905, AND COLLECTED JUST BEFORE THAT DATE.

MALE.

(1) 15.1cm., *immature*.—Otolith shows two zones, the third of the current year may have begun, but shows no distinct contrast with the second zone. The scales also show two zones, but not so easily distinguished.

FEMALES.

(1) 12cm. long, *immature*.—Only one zone, or central area; fish, therefore, one year old (fig. 9, pl. vii.).

(2) 14cm., *immature*.—Otolith shows only one undivided area, may be considered one year old. Scales also show no division into zones.

(3) 15cm., *immature*.—Two distinct zones in otolith, outer zone sharply defined from central region, indicating two years' growth.

(4) 15cm., *immature*.—Two distinct zones in otolith; the central region is much smaller than the whole otolith of (2), and does not show distinct lamination as that does. The calcified cartilage of the coracoid also shows two zones, but the boundary line is rather faint.

(5) 16.7cm., *immature*.—Otolith with central region and one outer zone separated by distinct boundary line. On the outer border there are a few opaque layers, which may be the commencement of this year's deposit, but they are not defined by a distinct boundary from the second zone.

(6) 20.7cm., *immature*.—Otolith shows four distinct zones. It seems difficult to believe that this fish, not quite 8½ inches long, and quite immature, should be really four years old, in which case it would be at least five years of age before it spawned for the first time.

(7) *Plaice*, 22.9cm., *immature*.—Only one distinct boundary, with very dark and opaque layers outside it. Several fainter lines in the central area, but these I regard as all occurring in the first year's growth.

With the exception of (1), (2), and (6), therefore, all these specimens were two years old and at the commencement of their third year.

LARGER PLAICE, CAUGHT 21 MILES S.S.E. OF ABERDEEN, ABOUT MARCH 8, 1905.

MALE.

(1) 26.7cm., *immature*.—Testes a mere narrow band along the anterior interspinous bone at posterior border of body cavity. Otolith shows three complete zones, with no distinct indication of the beginning of the fourth. May be taken to be three years old.

FEMALES.

(1) 29cm. long, *immature*.—Five distinct zones in otolith. It would appear, therefore, that this fish would be at the end of its sixth year when it began to spawn.

(2) 34.7cm., *immature*.—Ovary very small, without yolked eggs. Four complete zones in otolith, last one scarcely as wide as the others, but still too wide to be considered the deposit of the season now commencing.

(3) 37.5cm., *immature*.—Otolith shows five distinct zones, including, of course, the central area. The fish, therefore, five years old. The fifth zone is not quite so wide as the fourth. In the scales also five zones can be distinguished, but not so certainly or clearly as in the otoliths.

In the coracoid four complete zones are visible, and an outer fifth, which is narrower. In the sub- and inter-operculum I can make out no distinct zones or boundary lines.

(4) 50cm. (about 1 ft. 8 in.) mature, with ripe ovaries.—In the right otolith six complete zones visible and a peripheral seventh. I was in some doubt whether this last was the seventh annual growth in progress, or whether it was really complete in the preceding winter and the eighth about to commence. The latter view seems more probable, so that this fish is seven years old. As it is far beyond the limit of size for immature plaice, it may have spawned either once or several times previously.

The zones in the scales were rather difficult to distinguish, but there were apparently seven, including the central region and the extreme external zone. In the coracoid also there were visible six complete zones and a seventh at the periphery. The latter was narrower than the others, and opaque, like the commencement of a year's growth. At present I do not know when the new growth commences, but in examining other specimens subsequently I have assumed that the outermost zone in specimens collected in March and April represents the last complete year, and not the commencement of the new annual growth.

HEADS AND PECTORAL REGIONS OF PLAICE SENT FROM ABERDEEN, 16TH DECEMBER 1904: SEX NOT STATED.

(1) 26.2cm. ($10\frac{1}{2}$ inches actual measurement).—Otolith shows three zones, that is to say central area, complete second zone, and external zone. The fish is therefore in its third year; the third year would be completed some time in the commencement of next year.

(2) 31.2cm. ($12\frac{1}{2}$ inches actual measurement).—Otolith shows same condition, indicating that the fish is in its third year. If I understand him aright, this would be placed by Heincke in the second group, plaice which have lived two complete years and are in their third. In this case, the fish is larger than the maximum for this age of plaice on the Sylt grounds off the German coast (fig. 12).

(3) 35cm. (14 inches actual measurement).—Otolith shows four complete zones, and a fifth at the margin. Same number could be made out in the scales, in the coracoid, and in the conical hollow on the faces of the vertebræ (pl. viii., fig. 11 otolith, fig. 10 scale).

(4) 37.5cm. (15 inches actual measurement).—The otolith shows seven zones, including both the central area and peripheral zone. According to this, the fish was in its seventh year (pl. vii., fig. 5). The first three zones are strongly separated, but the fourth and sixth boundary lines were much less distinct, and it seemed possible that they might be accidental and not annual lines. In this case, however, the fourth and fifth zones would be of disproportionate width, so that it seems more probable that the fish is really in its seventh year and not in its fifth.

(5) 46.8cm. ($18\frac{3}{4}$ inches actual measurement).—The otolith shows five zones, including the peripheral one. In this specimen I examined the hollow of the vertebral centra and the coracoid, and have figured them (fig. 14). In these also five zones can be distinguished, though the central area of the vertebral surface is scarcely visible, that is to say it is difficult to make out its boundary line.

I also examined a large plaice 50.5cm. long, bought at a fishmonger's in London last autumn. The otolith showed six zones. The fish was a mature female, and was therefore in its sixth year.

COD FROM ABERDEEN, CAUGHT OCTOBER 1900.

Length of fish 8.6cm. ($3\frac{2}{3}$ inches). Length of scale from side of body .94mm., breadth .46mm. Number of concentric lines on scale 10 or 11. No winter zone. Age six or seven months.

SPECIMENS OF COD FROM ABERDEEN, CAUGHT NOVEMBER 10, 1904.

Of the following four specimens only parts of the skin and pectoral girdle were examined, so that only the scales give indications of age.

(1) *Length of fish 47.0cm. (1 ft. $6\frac{1}{3}$ in.), ♀, immature.*—Length of scale 2.4mm. Two winter zones distinguished. Within the first winter zone 9 or 10 rings, from first to second 19 or 20, outside the second 6 or 7. Age inferred two years and about six months. The rings in this and other cases are counted on the posterior part of the scale, as they do not all seem to extend round the whole scale.

(2) *Length of fish 54cm. (1 ft. $9\frac{3}{8}$ in.), ♂, immature.*—Number of lines in first annual zone 9 or 10, in second 13, in third 10, beyond 9. Probable age three years six months. I was not quite certain in this case about the number of winter zones in the outer part of the scale; the total number of complete annual zones may have been two or three, but three seemed more probable.

(3) *Length of fish 64cm. (2 ft. $1\frac{3}{8}$ in.), ♀, immature.*—First zone 10 lines, second 12 to 14 lines, third 12 lines, outside 8 or 9. Some doubt as in previous specimens. Age of fish three years six months, or possibly two years six months.

(4) *Length of fish 73cm. (2 ft. $5\frac{1}{2}$ in.).*—♂ with large testes but not ripe, probably mature. First zone 10 lines, second 12 to 15, third 12 to 15, beyond 4 or 5. Probable age three years six months.

SPECIMENS OF COD CAUGHT AT ABERDEEN ABOUT MARCH 9.

(1) *Length of fish 24.3cm. (10 in.).*—Otolith shows two annual zones. Scale also shows two zones; number of rings in first 13 or 14. Age inferred two years.

(2) *Length of fish 30.5cm. ($12\frac{1}{8}$ in.).*—Both scales and otolith indicate two annual zones. Inferred age two years.

(3) *Length of fish 30.7cm. ($12\frac{1}{4}$ in.).*—In the scales a single winter boundary zone is quite evident. It is also evident that the ridges are close together at the edge of the scale, showing that the winter growth was nearly or quite finished when the fish was killed. Inferred age two years. A transverse section of the otolith also showed two annual zones (pl. viii., fig. 16).

(4) *Length of fish 33.5cm. ($13\frac{3}{8}$ in.).*—In scales one complete annual zone and another outside it. It seemed as if the two or three outermost rings belonged to the commencement of the new summer's growth, but I was not sure of this. Number of rings in first annual zone 14–15, in second 16, beyond 3. Transverse section of otolith also showed two complete annual zones. Both in scales and otoliths a slight interruption was visible in the first summer's growth, but this did not seem to be a definite winter zone. Such an interruption might occur probably enough occasionally from unfavourable conditions. Age inferred two years.

The following specimens of cod were obtained at the same time, and the heads were sent to me, with labels indicating the size and condition of the fish:—

(1) *Length of fish 44.3cm. ($17\frac{3}{8}$ in.), $1\frac{3}{4}$ lbs. weight.*—♀ with small ovary, probably immature. Otolith in transverse section shows three annual zones. Inferred age three years.

(2) *Length of fish 45.6cm. (18½ in.), 2¼ lbs. weight.*—Scales behind head show two winter zones besides the external edge, in other words three annual zones. First zone 12 rings, second 17 to 19, third about 13. Otolith also shows three annual zones quite distinctly. Inferred age three years.

(3) *Length of fish 67.5cm. (2 ft. 3 in.), 8½ lbs. weight.*—♂ with small ovary, apparently immature. Scale from pectoral region shows three winter zones besides the outer edge, in other words four annual zones complete. The first zone contains 14 rings, the second 20, the third 16, the last only 7. It might be supposed that the last zone was only the commencement of the present season's growth, or, on the other hand, the fourth winter zone might not be complete, as the water is still cold in March. I thought it most probable that the fish was four complete years old. In the transverse section of the otolith four complete zones were visible. In this specimen I examined the pectoral girdle and the concave faces of the vertebræ. In the coracoid I could with difficulty make out three boundary lines in addition to the outer edge, but they were very indistinct, and would be untrustworthy without the other indications. In the hollows of the vertebræ there were numerous concentric lines, but the boundaries of annual zones were not distinct.

According to these latter results, the cod at two years of age is 10 to 13 or 14 inches in length, at three years 17 to 19 inches, at four years 27 inches; but of course it would require the examination of a large number of specimens to ascertain the average and range of sizes at these ages.

SPECIMENS OF COD FROM EXPERIMENTS DESCRIBED BY DR. FULTON IN TWENTY-SECOND REPORT OF THE BOARD (FOR 1903).

In the last Report Dr. Fulton, in his paper on "The Rate of Growth of Fishes," described certain experiments on the influence of temperature on the growth of cod and other fishes, experiments which were carried out in tanks in the Board's Marine Laboratory at Aberdeen. Several of the specimens which formed the subjects of these experiments were sent to me by Dr. Fulton, and I have examined them with the following results. Some of the specimens were from Tank I., in which the water was of the natural temperature, not artificially heated. Dr. Fulton does not give any dates in connection with these experiments, but I presume that the codling were put into the tank in the autumn of 1903. They were then from 12cm. to 15cm. long, or six inches and less. It is not certain, but seems most probable, that they were then in their first year. They were killed on August 4, 1904, and then sent to me.

(1) *Cod, Tank I., 20.4cm. long.*—The otolith in transverse section shows two annual zones, i.e. a central opaque region, then a zone of more transparent laminae, then a zone of opaque laminae again. The transparent zone corresponds to the previous winter, and the specimen supports the view that the opaque laminae are deposited in summer, as they extended almost to the edge, showing that they were being formed when the fish was killed in August. The specimens were preserved in formaline, and the skull bones were rather soft, but the layers of the otolith were not obscured. In the scales also a winter zone was visible, the ninth to twelfth rings being narrower and closer together.

(2) *24.8cm.*—In this also I made out two annual zones in the otolith, though the winter zone was not quite so transparent. In the scales the winter zone included rings 15 to 21 and was quite distinct, beyond it were only seven or eight rings.

These specimens, therefore, were in their second summer, according to

the structural indications, and this conclusion seems to be in accordance with the actual age.

Whiting from Tank I., 24.8cm. long.—Otolith shows one complete year and commencement of second, i.e. dark central region, then transparent zone, then dark external zone. The scales also show a distinct winter zone; there are 14 summer lines, then 12 winter lines, ending in a very distinct boundary of one or two very narrow rings; outside this boundary the new summer growth shows only seven or eight rings. Evidently the growth of the year is not very large even at the beginning of August. These whiting were 14cm. to 20cm. long when put into the tank, and it might be thought that they must then have been in their second year, but the structural indications are that the fish were only in their second year when killed.

Cod from Tank No. 4, length 36.6cm.; killed November 5, 1904.—I only received one specimen from this tank, which was kept artificially warm during the winter 1903–04. This, however, had not prevented the appearance of the boundaries between the annual zones of growth, for the transverse slice of the otolith distinctly showed two annual zones, and showed also a transparent zone externally in addition to the layers seen in the specimen killed in August. The scales also showed one winter zone at rings 15 to 20, and outside this 19 rings. To anyone who refers to Dr. Fulton's paper this will not seem surprising, for his tables show that, in spite of the artificial increase of temperature in the tank in winter, the cod grew nearly twice as fast in the last 55 days of the experiment than in the first 100. The growth was therefore slower in the winter, and the reduction of growth is shown by the winter zone in otolith and scales.

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- JENKINS, J. T.—"Altersbestimmung durch Otolithen bei Clupeiden." *Ibid*, Bd. vi., Abt. Kiel, 1902.
- FULTON, T. W.—"The Rate of Growth of Fishes." *Twenty-second Annual Report, Fishery Board for Scotland*, Part III., 1904.

DESCRIPTION OF PLATES.

PLATE VII.

- Fig. 1. Scale of Plaice, 8.7cm. long, caught near Aberdeen, May 1904. Zeiss a₂ Oc.3 camera.
- Fig. 2. Otolith of Plaice, 5.6cm. long, hatched in the spring of 1903, reared in small tank, and killed Nov. 5, 1904. Zeiss a₂ Oc.2.
- Fig. 3. Scale of same specimen, actual length 29mm. Zeiss A Oc.3.
- Fig. 4. Otolith of Plaice, 6.6cm. long, ♂, from Solway Firth, caught April 1905.
- Fig. 5. Otolith of Plaice, 37.5cm. (15 inches) long. Zeiss a₂ Oc.2. Shows seven zones, indicating apparently seven years of age.
- Fig. 6. Otolith of Plaice, 12.2cm. long, from Solway Firth, caught April 1905. Zeiss a₂ Oc.2 camera. Shows two annual zones.
- Fig. 7. Otolith of Plaice, 22.9cm. long, caught near Aberdeen, April 1, 1905. Zeiss a₂ Oc.2 camera.
- Fig. 8. Otolith of Plaice, 9.2cm. long, ♀ immature, from Solway Firth, April 1905. Zeiss a₂ Oc.2 camera.

Fig. 9. Otolith of Plaice, 12cm. long, ♀ immature, caught near Aberdeen, April 1, 1905. Shows only one year's growth.

PLATE VIII.

Fig. 10. Scale of Plaice, 35cm. long (14 inches), from Aberdeen. Zeiss A Oc.2. Shows five annual zones of growth.

Fig. 11. Otolith of same specimen. Zeiss a, Oc.2. Shows also five zones of growth, with slight irregularity in fourth zone.

Fig. 12. Otolith of Plaice, 31.2cm. long (12½ inches), from Aberdeen. Shows three annual zones.

Fig. 13. One of the anterior vertebrae of Plaice, 18½ inches long, from Aberdeen, showing the zones of growth in the concave face of the vertebra.

Fig. 14. Coracoid and scapula of same specimen, showing five zones of growth.

Fig. 15. Scale of Cod from Dr. Fulton's experiments, killed August 1904, in its second year. Zeiss A Oc.2 camera. Shows two annual zones.

Fig. 16. Cod, 30.7cm. long, caught near Aberdeen, March 1905. Transverse section of otolith, showing two annual zones of growth.

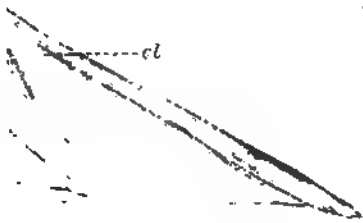
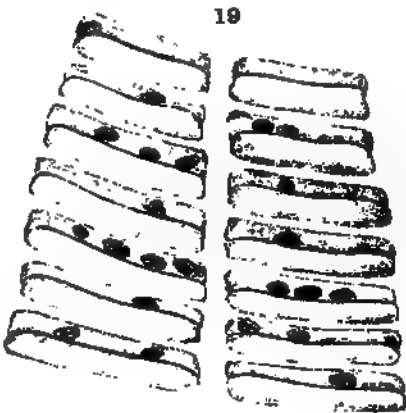
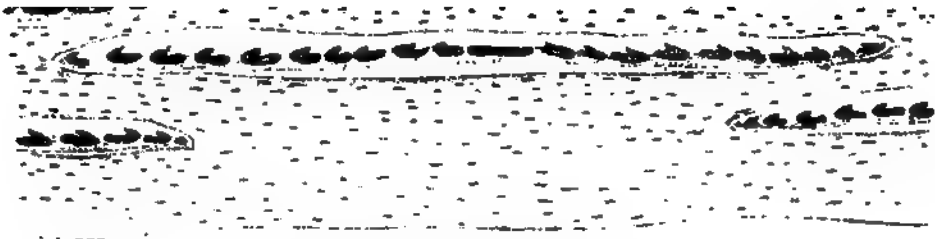
PLATE IX.

Fig. 17. Transverse section of skin of Cod from Dr. Fulton's experiments. Preserved with formaline. Zeiss A Oc.3.

Fig. 18. Portion of same section under higher power, to show nuclei on upper and lower surfaces of scale, and at edge.

Fig. 19. Surface view of scale of Whiting under higher power, showing nuclei on upper surface and their relation to the ridges of the sclerites.

Fig. 20. Pectoral girdle of Cod. Cl. = Cleithrum (clavicle). Co. = Coracoid. S. = Scapula.



VI.—ON SOME NEW AND RARE CRUSTACEA FROM THE SCOTTISH SEAS.

BY THOMAS SCOTT, LL.D., F.L.S., ETC.

(Plates X.—XIII.)

PRELIMINARY NOTE.

The Crustacea mentioned in the following notes were obtained for the most part in collections made during various Fishery investigations carried out under the direction of Dr. T. Wemyss Fulton, Scientific Superintendent of the Fishery Board for Scotland.

Several of the forms described appear to be new to science, others have not before been recorded from the Scottish seas, and one or two belong to a curious parasitic group of minute Copepoda found usually in the marsupium of Crustacean species belonging to the Amphipoda, Sympoda, and others of the smaller Malacostraca.

The following are the species described :—

Pseudocyclopia giesbrechti, Wolfenden—male described for the first time.

Euryte longicauda, Philippi, var. minor—new variety.

Longipedia coronata, Claus—new to Scottish fauna.

Stenhelia pygmaea, Norman and Scott—new to Scottish fauna.

Ameira elegans, sp. n.

Laophonte longiremis, sp. n.

Cletodes sarsi, sp. n.

Dyspontius curticaudatus, sp. n.

Spharionella aoræ, sp. n.

„ *vararensis*, sp. n.

„ *minuta*.

„ „ var.

„ sp. from *Hemilamprops rosea*.

Arcturella dilatata—now first recorded from the Forth estuary.

DESCRIPTION OF THE SPECIES.

SUB-ORDER CALANOIDA.

FAM. PSEUDOCYCLOPIIDÆ.

Genus *Pseudocyclopia*, T. Scott (1892). *

Pseudocyclopia Giesbrechti, Wolfenden. Pl. x., figs. 1–9.

1902. *Pseudocyclopia Giesbrechti*, Wolfenden, Journ. Mar. Biol. Assoc., Plymouth, vol. vi., No. 3, January, 1902, p. 370, pl. iv.

* *The Tenth Annual Report of the Fishery Board for Scotland, III.*, p. 246 (1892).

The female of this species was described and figured by Dr. Wolfenden in the Journal of the Marine Biological Association for January, 1902, but the male appeared to be unknown.

The male specimen (fig. 1), which I now propose to describe, agrees so closely with Dr. Wolfenden's definition and figures of the female that, after making allowance for sexual differences, I have no hesitation in ascribing it to the same species.

The cephalothorax is robust, and appears to be composed of only four segments, but the fifth is so small as to be almost entirely obscured by the fourth; the abdomen is slender and much shorter than the body; rostrum not much produced. The length of the specimen figured is about .8mm. (about $\frac{1}{31}$ of an inch).

Antennules (fig. 1) moderately slender, except towards the proximal end; they are shorter than the cephalothoracic segment, and composed of seventeen joints; the basal joint is large and stout and rather more than half as long as the entire length of the remaining joints, which are all short—the tenth, fourteenth, fifteenth and last are, however, rather longer than any of the other twelve. The formula shows approximately the proportional lengths of all the joints:—

Proportional lengths of the joints,	58	·	5	·	6	·	4	·	3	·	4	·	4	·	7	·	7	·	9	·	6	·	6	·	7	·	9	·	12	·	8	·	10
Numbers of the joints, -																																	

Posterior antennæ, outer ramus scarcely so long as the inner one, and composed of five joints—the third and fourth joints are very small and sparingly setiferous (fig. 3).^{*} Mouth appendages similar to those of the other described species.

All the four pairs of swimming feet (figs. 4–7) are also similar to those of the other described species, except that they are rather more hispid, but especially the inner branches of the fourth pair, and the outer branches also to some extent. In this pair the joints are more or less covered with minute prickles, as shown in the drawing (fig. 7), and the same character distinguishes the fourth pair in the female described and figured by Dr. Wolfenden.

Fifth pair are elongated and unequal on the two sides; the left leg is long and slender, for though the first and second joints are short, the other is of considerable length, and is probably longer than the drawing shows it, as the extremity is apparently slightly damaged; a dense fringe of small delicate hairs extends along part of the proximal half of the inner margin of the slender end joint, and terminates distally at a small hook-like process (fig. 8). The right leg is considerably dilated at the proximal end of the second joint, but becomes attenuated towards the distal extremity; the third joint is narrow, and terminates interiorly in one or two finger-like processes; while the end joint, which is very slender, and tapers gradually to a pointed apex, is furnished with a small process exteriorly near the proximal end, as shown in the drawing (fig. 8.). The abdomen is composed of five moderately short segments, and the furcal joints are also short (fig. 9).

Habitat.—Firth of Forth, west of Queensferry. Dredged Nov. 17, 1893, but only now described and figured.

Remarks.—One of the characters peculiar to the genus *Pseudocyclopia* is the presence of a long, moderately stout spine which springs from the inner distal angle of the first basal joint of the third pair of legs and reaches to about the end of the inner branch, as shown in figure 6.

^{*} Dr. Wolfenden describes the posterior antennæ as one-branched, but the outer ramus so characteristic of the *Pseudocyclopiidæ* as of the other *Calanoida* had probably become accidentally detached, and had thus given to the posterior antennæ an appearance somewhat unique among *Calanoida*.

SUB-ORDER CYCLOPOIDA.

FAM. CYCLOPIDÆ.

Genus *Euryte*, Philippi (1843).

Euryte longicauda, Philippi, var. *minor*. Pl. x., figs. 13 and 14.

Euryte longicauda is a moderately common species, and has already been recorded from the Firth of Forth and other places. Two forms, a smaller and a larger, have occasionally been observed, but they appear to differ very little from each other except in size. Figures 10 and 13 on plate x. show a female of the usual size and one of the small variety. The first measures about 1.2mm. and the other .8mm. in length; the drawings of them are similarly enlarged. But though they differ so distinctly in size, there appears to be scarcely any structural difference between them: for convenience sake, however, the small form might be distinguished as var. *minor*. The fifth foot in this variety is slightly different in shape and armature from that of the other, as shown by figures 12 and 14. Both of the forms represented here are from South Bay, Firth of Forth.

SUB-ORDER HARPACTICOIDA.

FAM. LONGIPEDIIDÆ.

Genus *Longipedia* (1863).

Longipedia coronata, Claus. Pl. x., figs 15-17.

Prof. G. O. Sars has shown that the *Longipedia* usually recorded from Scottish waters as *Longipegia coronata*, Claus, was not the species described by him under that name, but another and quite distinct form to which he has given the new name of *Longidepia Scotti*.* The true *L. coronata*, Claus, appears to be moderately rare in our seas, and is probably limited to moderately deep water. I have only observed it in two gatherings, and they were on each occasion collected in over fifty fathoms. *Longipedia coronata*, Claus, which is scarcely so large as *L. Scotti* shows several minute points of difference from the other species, i.e., the arrangement of the three prominent setæ on the long end-joint of the inner branches of the second pair of legs in the female is similar to that of *L. minor*, Scott, but there are short stout spine-like processes at the distal end of the basal joints of the outer and inner branches (fig. 15). The fifth pair of feet, though similar to those of *L. Scotti*, are slightly different in form and armature (fig. 16); while the last segment of the abdomen bears two short stout spines on each side of the prominent medium spine on the posterior dorsal margin (fig. 17).

Habitat.—Moray Firth, off Fraserburgh, September 29, 1904, collected by Dr. H. C. Williamson, to whom I am indebted for the specimens. The same species was also obtained in one of the "Gold-seeker" gatherings, and is recorded in the Bulletin of the Council of the International Bureau for November, 1904.

* Sars' Crustacea of Norway, vol. v., p. 11, pl. v., fig. 1 (1904).

FAM. STENHELIDÆ.

Genus *Stenhelia*, Boeck (1864).*Stenhelia pygmæa*, Norman and Scott.1905. *Stenhelia pygmæa*, N. and S., Ann. and Mag. Nat. His. (7), vol. xv., p. 284.

This small species has recently been noticed in a gathering of Crustacea collected at Station II., Firth of Forth, on December 26, 1894.* It was described by Norman and Scott from a specimen dredged near Eddystone Lighthouse by Rev. Canon A. M. Norman.†

S. pygmæa is one of the smaller species belonging to this genus, and measures only about $\frac{1}{70}$ of an inch in length; it appears to differ from other described species by the peculiar structure of the antennules and of the first pair of swimming feet, and by the form and armature of the fifth pair.

Genus *Ameira*, Boeck (1864).*Ameira elegans*, sp. n. Pl. x., figs. 18 and 19; pl. xi., figs. 1–9.

Description of the Female.—The body, which is moderately elongated and slender, has a general resemblance to *Canthocamptus palustris*, but it is rather less robust and somewhat smaller; the specimen figured measured only .7mm. (nearly $\frac{1}{38}$ of an inch) in length (pl. xi., fig. 1).

Antennules moderately elongated, eight-jointed, and sparingly setiferous; the second joint is considerably longer, and the fifth and seventh smaller than the others (pl. xi., fig. 2). The formula shows the lengths:—

Proportionate length of the joints,	13	·	23	·	14	·	15	·	9	·	10	·	7	·	11
Number of the joints,	.	.	.	.	1	2	3	4	5	6	7	8			

The antennæ (posterior antennæ) are moderately large, and are each furnished with a small uniarticulate outer ramus bearing a few apical setæ (pl. xi., fig. 3).

Mandibles narrow, oblong, masticatory end obliquely truncated, and armed with small teeth; mandible palp small, the basal part furnished with two setæ at the extremity—one being stout and spiniform, and one plumose—and a small uniarticulate branch bearing a few setæ is articulated to the distal half of the basal part (pl. xi., fig. 4).

The second maxillipeds are stout, and armed with a moderately long terminal claw (pl. x., fig. 18).

The swimming feet resemble those of *Canthocamptus palustris*, but differ in a few minor particulars, as shown by the drawings. In the first pair, which are moderately stout, the first joint of the inner branches reaches to slightly beyond the end of the outer branch, the next two joints are short, but the end joint is rather longer than the other; in the outer branches the middle joint, which is slightly longer than the first or third has a small spine on the inner distal angle; all the three joints have the usual marginal spines—one on each of the first and second joints, and three spines and two setæ on the lower half of the outer margin and end of the third joint (pl. xi., fig. 5).

In the second, third, and fourth pairs the inner branches are all shorter than the outer. The middle joint of the second pair bears a single setæ on the inner distal angle; but the end joint, which is rather longer than

* This gathering was only partially examined at the time it was collected, and it has not even yet been exhaustively dealt with.

† Cf. Ann. and Mag. Nat. Hist. for March, 1905, p. 284.

the other two, is provided with two setæ on the inner margin, two spines on the outer margin, and also with two long spines of unequal length and a long seta at the apex; the inner branches have the outer edge of each joint fringed with minute bristles, and a moderately long seta springs from the distal angles of the first and second joints and from the lower half of the third joint; the third joint is also armed with a terminal spine and two long terminal setæ (pl. xi., fig. 6).

The armature of third and fourth pairs is similar to that of the second, except that there are two setæ instead of one on the lower half of the inner margin of the last joint of the inner branches (pl. x., fig. 19, and pl. xi., fig. 7).

The fifth pair resembles, to some extent, the same appendages in female specimens of *Canthocamptus palustris*, but the inner portion of the primary joints, which are broadly sub-triangular, have the apex more or less distinctly truncated rather than rounded. The armature of the inner portion of the primary joints consists of five apical setæ, of which the three inner ones and the outermost are only of moderate length, but the other—the second from the outside—is greatly elongated. The secondary joints are oblong, with the outer and inner margins nearly parallel, the length being equal to about twice the width at the broadest part; outer margin nearly straight, inner slightly convex, apex obliquely truncate and furnished with six setæ; the second from the inside is very long, while the second from the outside is short; the others are of varying lengths, as shown in the drawing (pl. xi., fig. 8). Furcal joints very short (pl. xi., fig. 9).

Habitat.—West of Dunbar, near low water, collected by hand-net October 16, 1894, as well as in a collection from Musselburgh collected the same year; rare.

Remarks.—Though this species resembles *Canthocamptus palustris* in some respects, the difference in the proportional lengths of the joints of the antennules and of the outer and inner branches of the first pair of swimming feet, and also in the form of the fifth pair, and especially of the secondary joints of that pair, is sufficient to distinguish it.

FAM. LAOPHONTIDÆ.

Genus *Laophonte*, Philippi (1840).

Laophonte longiremis, sp. n. Pl. xi., figs. 10–20.

Description of the Female.—Body slender, and somewhat similar to *Laophonte thoracica* in general appearance. The cephalothoracic segment is equal in length to the next three taken together, gibbous on the under side, the ventral margins boldly rounded, the depth being nearly equal to the length of the segment; the remaining segment short. Furcal joints about equal in length to the last abdominal segment. Length of the specimen represented by the drawing (fig. 10) .6mm. (about $\frac{1}{4}$ of an inch).

Antennules long, slender, and composed of seven joints (fig. 11); first and second joints subequal, considerably longer than the first, the next three small, but the end joint is nearly as long as the combined lengths of the three preceding joints, as shown in the formulæ:—

Proportional lengths of the joints,	-	16	·	25	·	22	·	7	·	4	·	7	·	16
Number of the joints,	-	1		2		3		4		5		6		7

A long, slender, sensory filament springs from the upper distal angle of the fourth joint, as shown in the drawing.

The posterior antennæ are moderately slender and elongated, and the end joint is armed with a hook-like process on the outer distal angle in addition to the usual terminal setæ (fig. 12); outer ramus small, uniarticulate, and provided with two marginal and two terminal setæ.

Mandibles small and armed with a few bluntly-rounded teeth on the biting edge; palp small and furnished with a minute uniarticulated branch (fig. 13).

Maxillæ and first maxillipeds as in *L. thoracica*.

Second maxillipeds also similar to those of that species, the terminal claw being long and slender (fig. 14).

In the first pair of natatory legs the inner branch has the joint slender and nearly twice the length of the entire outer branch, and it bears a few minute bristles on the inner margin; the end joint is small and armed with a moderately stout and elongated claw. The outer branches are composed of three subequal joints, but the last is rather smaller than either of the other two (fig. 15). Outer branches of the second, third, and fourth pairs all three-jointed, elongated, and slender, and bearing long slender spiniform marginal setæ and very long terminal bristles, as shown by the drawing (figs. 16–18); inner branches short, two-jointed, and scarcely reaching to the second joint of the outer branches; first joint considerably shorter than the second, and each furnished with a single seta near the end of the inner margin; the end joint of the inner branches of the second and fourth pairs has a single seta on the lower half of the outer margin, two on the inner margin, and two at the apex; but in the third pair there are three setæ on the inner margin of the end joint of the inner branches.

Moreover, a single seta springs from near the middle of the inner margin of the end joint of the outer branches of the second pair, and two from the inner margins of the same joints of the third and fourth, but otherwise the armature of the outer branches of the second, third, and fourth pairs is much alike.

Fifth pair of moderate size, primary joint broadly oblong; the inner distal angle slightly produced, and furnished with three setæ on the inner margin—one being near the middle and two near the distal end; the produced part bears one seta also on its inner margin and three others of small size and unequal length at its apex. The primary joint also carries a slender spiniform seta on the outer distal angle; the secondary joint is narrow and elongated, the length being equal to fully four times the width at the broadest part; it is provided with about four setæ on the outer margin, one on the inner margin, and one on the produced and narrow apex (fig. 19).

Habitat.—In an old quarry at Granton, Firth of Forth, which is open to the sea; collected August 25, 1894; rare. This species differs from any other known to me; no male has yet been observed.

FAM. CLETODEIDÆ.

Genus *Cletodes*, Brady (1872).

Cletodes Sarsi,* sp. n. Pl. xii., figs. 1–9.

Description of the Female.—This species is somewhat intermediate between *Cletodes neglecta* and *C. longicaudata*, but differs from *C. neglecta* in having longer furcal joints, and from *C. longicaudata* in the furcal joints of that species being still more elongated (fig. 1). The length of the specimen figured is about .5mm. ($\frac{1}{30}$ of an inch).

* Named in compliment to Herr Professor G. O. Sars, the eminent Norwegian carcinologist.

The antennules (fig. 2) are very short, and composed of five joints ; the length of the second joint is about equal to that of the last, but the penultimate joint is very small, as shown by the formula :—

Proportional lengths of the joints,	-	5	·	13	·	9	·	2	·	13
Number of the joints,	-	1		2		3		4		5

The posterior antennæ are of moderate size, the end joint has the inner margin fringed with minute bristles, while two short setæ spring from the distal half of the same margin ; the outer rami is very small and unarticulate, and furnished with two or three setæ (fig. 3).

The mandible, maxillæ, and first maxillipeds are similar to those of *C. neglecta*. The second maxillipeds are very small, the end joint has the inner margin fringed with fine bristles and bears a long and very slender claw (fig. 4).

All the four pairs of swimming feet are moderately short, and are somewhat similar to each other in structure ; the outer branches are three-jointed and bear moderately long, slender spines or setæ ; the end joints of the outer branches of the first and second pairs are each provided with four terminal setæ, but the third and fourth pairs have five setæ round the end of the last joint ; these joints of the third and fourth pairs also differ from those of the first and second in that they become gradually and distinctly broader towards the distal extremity, as shown in the drawing (figs. 7 and 8) ; the inner branches are all two-jointed, short, and narrow ; the first joint is very small, but the second is elongated ; the inner branches in the first pair scarcely reach beyond the end of the second joint of the outer branches, while in each of the second, third, and fourth pairs the inner branches are slightly shorter than those of the preceding pair ; the inner branches of the first and second pairs are each furnished with two, and the others with three, terminal setæ (figs. 5–8).

The fifth pair are small ; the primary joint, which is very short, is produced interiorly into a narrow plate, which becomes somewhat wider towards the distal end, and is furnished with a short and moderately elongated spine, which is articulated to a notch near the middle of the inner margin, and also with a stout and moderately long spine and an elongate seta on the truncate apex ; the secondary joint is long and very narrow ; a short seta springs from near the middle and another from near the distal end of the outer margin. Moreover, a moderately long and spini-form seta springs from near the distal end of the inner margin of the secondary joint, and there is also a slender apical seta (fig. 9).

The furcal joints are rather longer than the combined lengths of the last two abdominal segments, and they each bear a small bristle on the upper half of the outer margin and another on their dorsal aspect.

Habitat.—Firth of Forth, 1901 ; rare.

FAM. HARPACTICIDÆ.

Genus *Harpacticus*.

Harpacticus uniremis, Kröyer. Pl. x., fig. 20.

This species, which is so fully described and figured by Professor G. O. Sars in the new volume of his Crustacea of Norway now in course of publication, has been observed in one or two places round the Scottish and English coasts—I have even obtained it in material washed from the filters in use at the hatchery at the Bay of Nigg.

In this species the limbs are strongly hispid, and it is otherwise quite distinct from the other described species belonging to the genus found on

our shores. Figure 20 in plate x. shows one of the fifth pair of thoracic feet of a female specimen.

FAM. ASTEROCHERIDÆ.

Genus *Dyspontius*, Thorell (1859).

Dyspontius curticaudatus, sp. n. Pl. xiii., figs. 1-10.

Description of the Female.—Length .8mm. (about $\frac{1}{31}$ of an inch); somewhat similar to *Dyspontius striatus* in general appearance, but considerably smaller, except that the abdomen is also distinctly shorter, and the cephalosome rather more distinctly triangular in front. The abdomen and furcal joints are very short, and are together scarcely longer than the combined lengths of the preceding segments of the metasome (fig. 1).

The antennules are short, moderately stout, sparingly setiferous, and composed of eight joints; second and last joints subequal and longer than any of the others; the fourth is short, being only about half the length of the joint on either side, as shown in the annexed formula:—

Proportional lengths of the joints,	14	·	25	·	10	·	5	·	10	·	8	·	10	·	23
Numbers of the joints,	1		2		3		4		5		6		7		8

A short sensory filament springs from about the middle of the end joint (fig. 2).

The antennæ (posterior antennæ) are moderately elongated, four-jointed, and armed with three moderately stout terminal spines, the middle one being considerably elongated and the outer very small; the outer ramus is rudimentary (fig. 3). The siphon reaches to about the end of the cephalosome.

The mandibles are very slender, and a small portion of the distal end of the inner margin is coarsely dentate, as shown in the drawing (fig. 4).

The maxillæ are somewhat similar to those of *Dyspontius striatus*, but are rather stouter, and the inner ramus is proportionally scarcely so elongate, being only slightly longer than the outer ramus; the terminal setæ of the outer and inner rami are also similar to those of that species (fig. 5).

The first maxillipeds resemble those of *Dyspontius fringella*, Giesb., very closely; they are furnished with a small fringe of setæ near the end of the second joint; the terminal claw is moderately short (fig. 6).

The second maxillipeds have the second joint elongated, but the third and fourth, which are subequal in length, are together not much more than half the length of the second joint; the terminal claw is stout and moderately short, and about equal to the combined lengths of the two preceding joints (fig. 7).

The swimming feet resemble those of *Dyspontius striatus*. In the first pair neither of the two branches bear terminal spines; the first joint of the outer branch, which is nearly twice as long as the next, carries a short seta on the distal angle of the outer margin, and another on the lower half of the inner margin; the second joint bears a short spine on the outer angle and a seta on the inner margin, while the last joint is furnished with two small spines on the outer margin, two setæ on the inner margin and two more setæ at the apex; the first joint of the inner branches bears one and the second two setæ on their inner margin, while the third carries three on the inner margin, one small seta on the outer margin, and two of moderate length at the apex, as shown in the drawing (fig. 8); the second pair, which were somewhat similar to the third, were damaged and no

drawing is given of them. In both branches of the third pair the armature of the first and second joints resembles that of the same joints in the first pair, but in the third joint of the outer branches there are three short spines on the outer margin, five setæ on the inner margin, besides a moderately stout terminal spine; while that of the third joint of the inner branches has three setæ on the inner margin, a small seta on the outer margin, and a stout spine with a seta in front of it at the apex (fig. 9).

In the fourth pair the outer branches only are developed, and resemble the outer branches of the third pair; the inner branches are represented by a minute digitiform process (fig. 10).

The fifth pair very minute.

Habitat.—Dredged in the vicinity of Culross, a few miles above Queensferry, Firth of Forth.

This form is in some respects similar to *Dyspontius striatus*, but it differs in having only eight-jointed antennules and in the abdomen being very short. The male is unknown.

FAM. NICOTHOIDÆ.

Genus *Nicothoë*, Aud, and M. Edw., 1826.

Nicothoë astaci, Audouin and M. Edwards.

1826. *Nicothoë astaci*, Aud. and M. Edw., Ann. Sci. Nat., 1st ser., vol. ix., p. 345, taf. 49, figs. 1-9.

Dr. H. C. Williamson, while examining a lobster sent to him from Dunbar, observed this curious parasite adhering to one of the gills and kindly handed it over to me. This is the first specimen of *Nicothoë* I have seen from the Forth district. The distribution of this species, so far as concerns the British Islands, appears to be coextensive with its host.

FAM. CHONIOSTOMATIDÆ.

Genus *Sphæronella*, Salensky (1868).

Sphæronella minuta, T. Scott. Pl. xii., fig. 18; pl. xiii., fig. 16.

This small form—parasitic on the Amphipod *Periocolodes longimanus* (Spence Bate)—was described in Part III. of the Twenty-second Annual Report of the Fishery Board for Scotland, published in 1904 (pl. xv., figs. 11-15). One or two more specimens of *Periocolodes* infested with the same species of *Sphæronella* were recently observed in gatherings of small Crustacea collected in the Moray Firth by Dr. H. C. Williamson, to whom I am indebted for the specimens. Figure 18, plate xii., shows a *Periocolodes* with a parasite *in situ*, and figure 16, plate xiii., shows an enlarged drawing of an adult female bearing two ovisacs, each of which is about as large as the parasite itself.

Sphæronella minuta, var. *valida*. Pl. xiii., fig. 17-20.

This form, which was obtained in the marsupium of an amphipod, *Melamphopus cornutus*, Norman, resembles *Sphæronella minuta* so closely except in size, that I can only regard it as a large variety of that species. The female, which is represented by the drawing (fig. 17, pl. xiii.), measures .73mm. in length, or about one and a half times the size of *S. minuta*. The body is globular in form and the appendages, so far as

they could be made out, appeared to be closely similar to the corresponding appendages in *S. minuta*. No males have yet been observed. The Amphipod was obtained in a gathering of small Crustacea collected off the east side of Inchkeith, Firth of Forth, in May, 1901.

Sphaeronella aore, sp. n. Pl. xii., figs. 10-17.

Female moderately large; its outline, when seen from above, had an obscurely quadrate appearance and was about as long as broad; the head forms a small rounded protuberance in front; length .86mm. (about $\frac{1}{30}$ of an inch); ovisacs large (fig. 10).

Antennules apparently four-jointed, but the end joint is very small; the penultimate joint, which is equal to about one and a half times the length of the one that precedes it, is furnished with a number of short setæ (fig. 12).

The first maxillipeds are uniarticulate, very robust, and armed with a stout terminal claw (fig. 14).

The second maxillipeds are moderately stout, elongated, and four-jointed; the second joint is as long as the third and fourth combined, while the third is narrower than the second and rather longer than the ultimate joint; terminal claw short and stout (fig. 15).

The male, which measures about .28mm. has a somewhat close resemblance to the male of *Sphaeronella chinensis*, H. J. H.* The cephalo-thoracic plate is widest posteriorly where the breadth is about equal to the length; the sides, which are nearly straight, converge towards the proximal end, which is trilobed, the median lobe being larger than that on either side, abruptly truncate in front and produced slightly beyond the lateral lobes, which are bluntly rounded. Posterior portion of the body short, semicircular in outline, and covered with short bristles (fig. 11).

The antennules of the male differ slightly from those of the female; they are rather shorter and stouter (fig. 13).

The second maxillipeds differ considerably from those of the female; the second joint is moderately stout, but comparatively shorter than in the second maxillipeds of the female, and furnished with two or three transverse rows of short bristles; the two end joints are slender, the ultimate one being very small and bearing a moderately stout claw (fig. 16).

The thoracic legs appear to be uniarticulate and armed with one long and one short terminal seta (fig. 17).

Habitat.—In the marsupium of *Aora gracila* (Bate), from a townet gathering collected in the Dornoch Firth by Dr. H. C. Williamson, which he kindly handed over to me for examination.

Sphaeronella vararensis, sp. n. Pl. xiii., figs. 12-15.

This *Sphaeronella* was found in the marsupium of an Amphipod, *Megaluropus agilis*, Norman, captured in Burghead Bay, Moray Firth, by Dr. H. C. Williamson, on Dec. 12, 1904, and kindly handed over to me along with some other interesting things. One or two females of this parasite were observed, but no males. The females are of an ovate form, widest in the middle, and nearly one and a half times longer than broad; head somewhat produced and broadly truncate in front. The specimen represented by the drawing measured .53mm. (about $\frac{1}{47}$ of an inch) and carried two ovisacs, each nearly as long as the parasite itself; the ovisacs were ovate in form, broadly rounded on the outer, but flattened on the

* The "Choniostomatidae," by H. J. Hansen, pp. 106 and 112, Pl. II. and Pl. III.

inner aspect (fig. 12). The female as seen from the side is moderately and evenly rounded on the dorsal aspect and somewhat flattened below, as shown in figure 13.

The antennules appear to be four-jointed, but the end joint is very small, while the penultimate joint is nearly as long as the preceding two joints taken together (fig. 14).

The second maxillipeds are moderately large and composed of four joints; the first and second joints are robust, and the second is considerably more elongate than the next two joints combined, which are short and narrow, and furnished with a short terminal claw (fig. 15). This form does not agree with any species known to me. No males were observed.

(?) *Sphaeronella* sp. from a *Hemilamprops rosea* (Norman).

A moderately large *Sphaeronella*, bright red in colour, was quite recently obtained in the marsupium of a specimen of *Hemilamprops rosea* (Norm.) captured in Loch Fyne by Dr. Williamson. So far as I am aware no *Choniostomaton* has yet been recorded from this species of the Lampropidæ.

ISOPODA VALVIFERA.

FAM. ARCTURIDÆ.

Genus *Arcturella*, G. O. Sars, 1897.

Arcturella dilatata, G. O. Sars. Pl. xiii., fig. 11.

1897. *Arcturella dilatata*, G. O. Sars, Crustacea of Norway, vol. ii., p. 92, pl. xxxviii.

A male specimen of this species was obtained in some material dredged off St. Monans on May 22, 1901. The species appears to be widely distributed, but moderately rare. The late Dr. Robertson has recorded this species from the Firth of Clyde, and I have observed one or two specimens in gatherings dredged off Fair Island in October, 1900.

DESCRIPTION OF THE PLATES.

PLATE X.

Pseudocyclopia giesbrechti, Wolfenden.

							Diam.
Fig. 1.	Male, side view	.	.	.	.	.	x 90.
Fig. 2.	Antennule	.	.	.	.	.	x 260.
Fig. 3.	Antenna	.	.	.	.	.	x 260.
Fig. 4.	Foot of first pair	.	.	.	.	.	x 260.
Fig. 5.	Foot of second pair	.	.	.	.	.	x 260.
Fig. 6.	Foot of third pair	.	.	.	.	.	x 260.
Fig. 7.	Foot of fourth pair	.	.	.	.	.	x 260.
Fig. 8.	Foot of fifth pair	.	.	.	.	.	x 260.
Fig. 9.	Abdomen and furcal joints	.	.	.	.	.	x 195.

Euryte longicauda, Philippi.

Fig. 10.	Female, dorsal view	.	.	.	.	.	x 90.
Fig. 11.	Antennule	.	.	.	.	.	x 195.
Fig. 12.	Foot of fifth pair	.	.	.	.	.	x 390.

Euryte longicauda, var. *minor*.

Fig. 13. Female, dorsal view	.	.	.	.	.	x	90.
Fig. 14. Foot of fifth pair	.	.	.	.	.	x	390.

Longipedia coronata, Claus.

Fig. 15. Foot of second pair, female	.	.	.	.	.	x	90.
Fig. 16. Foot of fifth pair, female	.	.	.	.	.	enlarged.	
Fig. 17. Last segment of abdomen and furcal joints	.	.	.	.	.	x	195.

Ameira elegans, sp. n.

Fig. 18. Second maxilliped, female	.	.	.	.	.	x	780.
Fig. 19. Foot of third pair	x	260.

Harpacticus uniremis, Kröyer.

Fig. 20. Foot of fifth pair	enlarged.	
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PLATE XI.

Ameira elegans, sp. n.

Fig. 1. Female, side view	x	60.
Fig. 2. Antennule	x	260.
Fig. 3. Antenna	.	.	.	.	.	x	390.
Fig. 4. Mandible	.	.	.	.	.	x	780.
Fig. 5. Foot of first pair	.	.	.	.	.	x	260.
Fig. 6. Foot of second pair	.	.	.	.	.	x	260.
Fig. 7. Foot of fourth pair	.	.	.	.	.	x	195.
Fig. 8. Foot of fifth pair	.	.	.	.	.	x	390.
Fig. 9. Last segment of abdomen and furcal joints	.	.	.	.	.	x	195.

Laophonte longiremis, sp. n.

Fig. 10. Female, side view	.	.	.	.	.	x	135.
Fig. 11. Antennule	.	.	.	.	.	x	520.
Fig. 12. Antenna	.	.	.	.	.	x	520.
Fig. 13. Mandible	.	.	.	.	.	x	780.
Fig. 14.	.	.	.	.	.	x	780.
Fig. 15. Foot of	.	.	.	.	.	x	300.
Fig. 16. Foot of second pair	.	.	.	.	.	x	260.
Fig. 17. Foot of third pair	.	.	.	.	.	x	260.
Fig. 18. Foot of fourth pair	.	.	.	.	.	x	260.
Fig. 19. Foot of fifth pair	.	.	.	.	.	x	390.
Fig. 20. Last segment of abdomen and furcal joint	.	.	.	.	.	x	195.

PLATE XII.

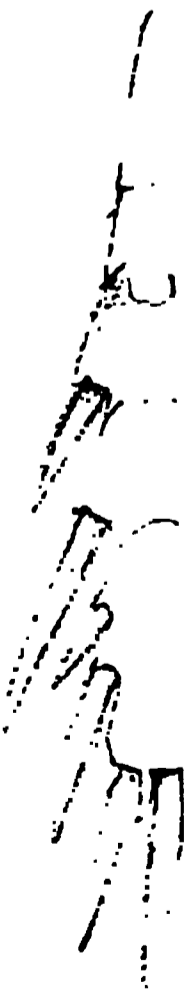
Cletodes Sarsi, sp. n.

Fig. 1. Female, dorsal view	.	.	.	.	.	x	180.
Fig. 2. Antennule	.	.	.	.	.	x	780.
Fig. 3. Antenna	.	.	.	.	.	x	780.
Fig. 4. Second maxilliped	.	.	.	.	.	x	780.
Fig. 5. Foot of first pair	.	.	.	.	.	x	780.
Fig. 6. Foot of second pair	.	.	.	.	.	x	780.
Fig. 7. Foot of third pair	.	.	.	.	.	x	780.
Fig. 8. Foot of fourth pair	.	.	.	.	.	x	780.
Fig. 9. Foot of fifth pair	.	.	.	.	.	x	780.

Spheronella aora, sp. n.

Fig. 10. Female, dorsal view	.	.	.	.	.	x	60.
Fig. 11. Male, dorsal view	.	.	.	.	.	x	180.

F. B. :



A. SCOTT,





n



Fig. 12.	Antennule, female	.	.	.	.	.	.	x	780.
Fig. 13.	Antennule, male	.	.	.	.	.	.	x	780.
Fig. 14.	First maxilliped, female	.	.	.	.	.	.	x	780.
Fig. 15.	Second maxilliped, female	.	.	.	.	.	.	x	780.
Fig. 16.	Second maxilliped, male	.	.	.	.	.	.	x	780.
Fig. 17.	Foot of ? second pair	.	.	.	.	.	.	x	390.

Sphæronella minuta, T. Scott.

Fig. 18.	<i>Periocolodes longimanus</i> with the <i>Sphæronella</i> in situ,	x	22.5.
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PLATE XIII.

Dyspontius curticaudatus, sp. n.

Fig. 1.	Female, dorsal view	x	80.
Fig. 2.	Antennule	x	263.
Fig. 3.	Antenna	.	.	.	.	.	.	x	520.
Fig. 4.	Mandible	.	.	.	.	.	.	x	390.
Fig. 5.	Maxilla	.	.	.	.	.	.	x	520.
Fig. 6.	First Maxilliped	.	.	.	.	.	.	x	350.
Fig. 7.	Second maxilliped	.	.	.	.	.	.	x	280.
Fig. 8.	Foot of first pair	.	.	.	.	.	.	x	187.
Fig. 9.	Foot of third pair	.	.	.	.	.	.	x	260.
Fig. 10.	Foot of fourth pair	x	260.

Arcturella dilatata, Sars.

Fig. 11.	Male, dorsal view	x	20.6.
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Sphæronella vararensis, sp. n.

Fig. 12.	Female, dorsal view	x	90.
Fig. 13.	Female, side view	x	120.
Fig. 14.	Antennule	.	.	.	.	.	.	x	780.
Fig. 15.	Second maxilliped	x	780.

Sphæronella minuta, T. Scott.

• Fig. 16.	Female, with ovisacs
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Sphæronella minuta, var. *valida*.

Fig. 17.	Female, dorsal view	x	72.
Fig. 18.	Female, side view	x	780.
Fig. 19.	Antennule	.	.	.	.	.	.	x	780.
Fig. 20.	Second maxilliped	.	.	.	.	.	.	x	780.

VII.—A NOTE ON THE HATCHING OF THE CRAB (*CANCER PAGURUS*). By H. CHAS. WILLIAMSON, M.A., D.Sc., Marine Laboratory, Aberdeen.

In the summer of 1902 a quantity of the fry of the edible crab was distributed in the sea off the coast of Aberdeenshire.

Nine berried crabs (breester, pea-parten) were obtained chiefly in the neighbourhood of Aberdeen. They were kept in two concrete tanks until the larvæ hatched out. Shelter was afforded the crabs in cavities formed by building stones up on the sand-covered bottom of the tank. When the fry hatched out it was attracted to the glass front of the tank, from which side the light entered, and when present in quantity the fry formed a thick white cloud. The young crabs were drawn off into the carboys by means of a syphon. All the fry of the crab deposited near Fraserburgh and Findochty was in the first zoëa stage. The crab fry was disposed of as follows:—

August 6, 1902.—About 1 million set free about 1 mile north of Fraserburgh.

August 7, 1902.—About 2 millions set free about $\frac{1}{2}$ mile off Cairnbulg.

August 19, 1902.—About 1 million set free about $\frac{3}{4}$ mile off St. Combs.

September 15, 1902.—About $\frac{1}{2}$ million set free about $\frac{3}{4}$ mile north of Findochty.

The method of estimating the numbers of crab fry was as follows. The fry that was set free was provided by nine berried crabs, and at the low average of half a million eggs to each crab, should number $4\frac{1}{2}$ millions. The proportion of this total set free at each of the four above-mentioned places was apportioned approximately by the number of carboys required for the consignment.

The crabs hatched out in August, September, and October. The vitality of the crab fry was tested in the following manner. Crab fry were crowded into a glass jar. The water was heated to $17\frac{1}{2}^{\circ}$ C., and then allowed to cool. Next forenoon the majority was alive and lively.

On one of the journeys the water in one of the carboys was cooled to about 7° C. The crab fry in this carboy did not, at the end of the journey, appear to be in any better condition than those which had been filled with water at the temperature of the hatchery.

The crabs which furnished the fry were kept alive when the hatching was finished, and some lived until the spring of 1905. The history of the members of the 1902 group throws some light on certain of the problems of the life-history of this species. It has been already outlined.*

In January 1903 two of these crabs were dissected; one had died, the second was killed. In the former the ovary was white, with a very slight pink tinge. There were a few red eggs in a bunch near the oviduct. The eggs were degenerating; they were disorganised internally.

* *Vide* Williamson. "Contributions to the Life-histories of the Edible Crab (*Cancer pagurus*) and of other Decapod Crustacea, &c."—*Twenty-second Annual Report of the Fishery Board for Scotland, Part III.*, 1904.

One spermatheca was empty ; the other had a large quantity of sperms in it. The swimmerets had still some empty egg-capsules attached. In the crab which was killed the ovary was the colour of the external eggs. It was friable. The spermatheca contained a good quantity of sperms. The endopodites of the swimmerets were clean.

In October 1903 two of the crabs spawned. One which was killed had an ovary that appeared to be ripe ; the eggs measured $\cdot 37$ and $\cdot 4$ mm. in diameter. There was a copious supply of sperms in the spermatheca.

On January 13th 1904 another crab was found to have spawned. On February 14th 1904 two of the non-berried crabs were dead. In one, measuring 6 inches across, the ovary was small and white, but mottled to a considerable extent here and there with red eggs. This crab had evidently spawned this season, although the eggs had not remained attached to the swimmerets. There was a small quantity of sperms in each spermatheca. The second crab measured $7\frac{1}{8}$ inches across. The ovary was dropsical. There was a large quantity of sperms in both spermatheca. There were lots of empty egg-capsules on the endopodites of the swimmerets.

On October 31st 1904 there were five crabs remaining of the 1902 batch. One was berried. On November 19th 1904 two of the crabs were berried. In December 1904 and January 1905, three crabs were found dead. On January 12th 1905 two crabs remained ; one of these was berried. Both crabs were found dead on May 6th 1905. During the whole period not one of the crabs cast.

CASTING.—THE ABSORPTION AREAS ON THE CHELA.

In a previous paper I described the absorption which takes place on the three proximal joints of the chela at the time when the crab casts, whereby the withdrawal of the chela from the shell is facilitated. I was not aware at that time that a detailed description accompanied by drawings had been published by J. Couch.*

* J. Couch. "A particular description of some circumstances hitherto little known, connected with the process of Exuviation in the Common Edible Crab." *Twenty-sixth Annual Report of the Royal Cornwall Polytechnic Society*, 1858.

VIII.—ON THE TAY SPRAT FISHERY,
1904–1905.

By JOHN FLETCHER, University College, Dundee.

The sprat fishing during the past season has been exceptionally poor. Only 1348 crans of sprats, including young herrings, were taken out of the river this season, as against 14,966 crans during the season of 1883–1884.

The 1348 crans consisted of somewhere about 44 million young herrings and sprats, of which some 52 per cent., or 23 million, were young herrings measuring from 4·3 centimetres to 17·5 centimetres in length, and the other 21 million, or 42 per cent., were sprats measuring from 4 centimetres to 15 centimetres.

Of the 1348 crans, some 894 crans were sold as fresh fish and sent off to the markets of London, Birmingham, Manchester, Liverpool, and other English towns; and some 454 crans (containing over 7 million young herrings) were sold to local farmers for manure.

The 894 crans of fresh fish brought to the fishermen a sum of somewhere about £220, and the 454 crans of manure brought in only some £20.

A certain number of young herrings and sprats were also destroyed while the men were engaged at the sparling fishing further up the river.

During October, November, and December, 1904, the number of sprat boats engaged at the sparling fishing varied from 5 to 20, and each net brought up along with the sparlings from 1 to 6 buckets of young herrings and sprats per day. During the latter half of January 1905 the number of boats varied from 10 to 26, and these were getting from 3 buckets to 1½ crans of young herrings and sprats. Very few were caught during the month of February.

The young of other fishes are also annually destroyed by the sprat and sparling fishermen, but apparently not in any great quantities. The useful forms include the young of the whiting, cod, plaice, dab, flounder, and sparling, while among the inedible kinds were young and adult *agoni*, *cotti*, *liparis*, lumpsuckers, sand-eels, sticklebacks, &c.

The Broughty-Ferry winter herring fishermen and the sprat fishermen strictly observed the line of division suggested at the Local Enquiry of January 1904, viz.:—a line drawn between Broughty-Ferry and Tayport, the sprat fishers being restricted to the part of the river above that line, and the Broughty-Ferry men never going beyond it.

During the course of this season's investigations 46 samples of mixed sprats, young herring, and other fish were bought and examined. The 46 samples consisted of:—

Young Herring,	26,037
Sprats,	16,992
Young Whiting,	317
„ Cod,	136
„ Plaice,	68
„ Sparlings,	26
„ Flounders,	18
„ Dabs,	15
„ Lythe,	1
	<hr/>
	43,610
	<hr/>
<i>Agonus cataphractus</i> ,	168
Sand-eels (<i>Ammodytes tobianus</i>),	40
Viviparous Blennies,	10
Lumpsuckers. <i>Cyclopterus lumpus</i> ,	9
<i>Gobius minutus</i> ,	9
Butter-Fish. <i>Centronotus gunnellus</i> ,	9
<i>Liparis montagui</i> ,	8
Pipe-fish, <i>Syngnathus</i> , sp.,	5
Fifteen-spined Stickleback,	2
Three-spined Stickleback,	1
	<hr/>
	261
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In most cases, also, the sprats and herrings were carefully measured with a view to determining the rate of growth of the species and the probable growth of the fish caught. These measurements will be dealt with on another occasion.

NUMBER OF SPRATS MEASURED.

October,	977
November,	3438
December,	2238
January,	2112
February,	2233
	<hr/>
	10,998
	<hr/>

NUMBER OF HERRING MEASURED.

October,	733
November,	2983
December,	2269
January,	2287
February,	1983
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	10,255
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The 43,000 sprats and young herring examined represented about one thousandth part of the entire season's catch. The catch was carefully inspected on every day when fish were landed throughout the season, but on some days no large samples were counted, a rough estimate only being made of the proportion of sprats and herrings which made up the catch. By these two methods the following Table has been drawn up, showing the approximate composition of the catch throughout the season. An asterisk denotes the days when the estimate was only a superficial one.

OCTOBER.

Date.	No. of Crans.	Estimated No. of Young Herring.	Estimated No. of Sprats.	Estimated Total No. of Fish.
1904.				
October 20 . .	13	2,520	47,880	50,400
„ 24 . .	4	39,168	76,032	115,200
„ 27* . .	1½	12,960	30,240	43,200
„ 28 . .	4	3,456	111,744	115,200
„ 31 . .	4½	33,048	89,352	122,400
	15½	91,152	355,248	446,400

NOVEMBER.

Date.	No. of Crans.	Estimated No. of Young Herring.	Estimated No. of Sprats.	Estimated Total No. of Fish.
1904.				
November 1 . .	15	30,240	401,760	432,000
„ 2 . .	34½	59,616	933,984	993,600
„ 3 . .	½	288	3,312	3,600
„ 4 . .	2	19,584	38,016	57,600
„ 5* . .	4	34,560	80,640	115,200
„ 7 . .	6	58,215	174,645	232,860
„ 10 . .	9	49,248	4,875,552	4,924,800
„ 11* . .	3	17,280	69,120	86,400
„ 12* . .	3	17,280	69,120	86,400
„ 14 . .	23	331,200	331,200	662,400
„ 15* . .	31½	272,160	635,040	907,200
„ 16 . .	58	668,160	1,002,240	1,670,400
„ 17* . .	30½	404,064	1,474,336	1,878,400
„ 18* . .	¾	3,240	7,560	10,800
„ 19* . .	1½	12,960	30,240	43,200
„ 21 . .	23½	257,184	419,616	676,800
„ 22* . .	49	987,840	423,360	1,411,200
„ 23 . .	16½	456,192	19,108	475,300
„ 24 . .	78½	1,763,424	497,376	2,260,800
„ 25* . .	24½	558,720	139,680	698,400
„ 26* . .	17½	403,200	100,800	504,000
„ 28 . .	32½	664,560	271,440	936,000
„ 29* . .	11½	236,880	101,520	338,400
„ 30 . .	10½	275,544	34,056	309,600
	485½	7,581,639	12,133,721	19,715,360

DECEMBER.

Date.	No. of Crans.	Estimated No. of Young Herring.	Estimated No. of Sprats.	Estimated Total No. of Fish.
1904.				
December 1* . .	3	69,120	17,280	86,400
„ 5 . .	1 $\frac{1}{2}$	20,160	30,240	50,400
„ 7 . .	66 $\frac{1}{2}$	896,760	1,011,240	1,908,000
„ 8* . .	68 $\frac{1}{2}$	982,800	982,800	1,965,600
„ 9 . .	9 $\frac{1}{2}$	191,520	82,080	273,600
„ 10* . .	4 $\frac{1}{2}$	90,720	38,880	129,600
„ 12 . .	23 $\frac{1}{2}$	534,672	142,128	676,800
„ 14 . .	9	150,336	108,864	259,200
„ 15* . .	2 $\frac{1}{2}$	45,360	19,440	64,800
„ 16 . .	$\frac{1}{2}$	6,696	504	7,200
„ 19 . .	5	100,800	43,200	144,000
„ 20* . .	50 $\frac{1}{2}$	876,960	584,640	1,461,600
„ 21* . .	35 $\frac{1}{2}$	613,440	408,960	1,022,400
„ 22 . .	7 $\frac{1}{2}$	116,928	91,872	208,800
„ 23* . .	35	504,000	504,000	1,008,000
„ 26* . .	24 $\frac{1}{2}$	211,680	493,920	705,600
„ 27 . .	17	141,984	347,616	489,600
„ 28* . .	27	233,280	544,320	777,600
„ 29* . .	13	112,320	262,080	374,400
„ 31* . .	5	43,200	100,800	144,000
	408 $\frac{1}{2}$	5,942,736	5,814,864	11,757,600

JANUARY.

Date.	No. of Crans.	Estimated No. of Young Herring.	Estimated No. of Sprats.	Estimated Total No. of Fish.
1905.				
January 4* . .	8½	151,200	100,800	252,000
„ 5 . .	19	377,568	169,632	547,200
„ 6* . .	9	155,520	103,680	259,200
„ 9 . .	4½	78,336	44,064	122,400
„ 10 . .	19	383,040	164,160	547,200
„ 13 . .	97½	2,212,632	588,168	2,800,800
„ 14* . .	22	506,880	126,720	633,600
„ 16 . .	4½	117,936	11,664	129,600
„ 17* . .	11	34,560	8,640	43,200
„ 18 . .	42½	861,840	369,360	1,231,200
„ 19* . .	64	1,474,560	368,640	1,843,200
„ 20 . .	66½	1,602,720	305,280	1,908,000
„ 21* . .	40	967,680	184,320	1,152,000
„ 23 . .	21½	532,440	93,960	626,400
„ 24* . .	2½	57,600	14,400	72,000
„ 25 . .	4	87,552	27,648	115,200
„ 26* . .	2	46,080	11,520	57,600
„ 27 . .	½	6,048	1,152	7,200
	428½	9,654,192	2,693,808	12,348,000

FEBRUARY.

Date.	No. of Crans.	Estimated No. of Young Herring.	Estimated No. of Sprats.	Estimated Total No. of Fish.
1905.				
February 1 . .	½	5,472	1,728	7,200
„ 3* . .	½	10,080	4,320	14,400
„ 7 . .	1	14,976	13,824	28,800
„ 8* . .	3½	51,480	42,120	93,600
„ 9 . .	2½	49,896	29,304	79,200
„ 13* . .	½	6,480	4,320	10,800
„ 14 . .	½	3,024	4,176	7,200
„ 20* . .	½	3,600	3,600	7,200
„ 23 . .	½	17,064	4,536	21,600
„ 24 . .	½	5,112	2,088	7,200
	9½	167,184	110,016	277,200

1904-1905.

Months.	Estimated No. of Crans.	Estimated No. of Young Herring.	Estimated No. of Sprats.	Estimated Total No. of Fish.	Estimated Percentage of Young Herring.
October, . . .	15½	91,152	355,248	446,400	20·4
November, . . .	485½	7,581,639	12,133,721	19,715,360	38·5
December, . . .	408½	5,942,736	5,814,864	11,757,600	50·5
January, . . .	428½	9,654,192	2,693,808	12,348,000	78·2
February, . . .	9½	167,184	110,016	277,200	60·3
	1,847½	23,436,903	21,107,657	44,544,560	50·4

It will be observed that the percentage of herring gradually and steadily increased from the commencement of the season until January, and was still at a high level when the fishing closed.

TAY SPRAT FISHING INVESTIGATIONS—1904-1905.

Causes of Failure of the Fishing.

This season's sprat fishing has been one of the poorest for many years, great distress prevailing amongst the fishermen during the first half of the season, or from October till the end of December.

During that time both fishermen and buyers were losing money, and, at most, the fishermen were only able to pay for the wear and tear of gear, dock dues, and victualling.

The principal causes of complaint were:—

- (1) The scarcity and poor quality of the fish.
- (2) The low prices obtained for the fish.
- (3) The alleged excessive railway rates.

The mild open winter, want of south-easterly gales, and almost total absence of spates may have something to do with the scarcity of fish in the river, but, so far, I have not been able to prove that such causes have any influence upon the movements of the fish.

As the bag-net captures all sizes and every kind of fish that enters the river, it follows that the very large numbers of young sprats and young herring, together with the usually considerable numbers of young cod, whiting, Agoni, shrimps, &c., all go to make up the so-called rubbishy stuff sent from Dundee to the English markets.

This mixture of fish has no chance beside the prime sprats sent from Inverness, where the fishing is carried on by means of drift-nets.

The railway companies charge from 6s. to 10s. per barrel for fish sent to the English markets. This rate is doubtless a severe handicap on the trade considering the small value of the produce, though it can scarcely be deemed high considering the bulk of the goods and the distance from Dundee to the great English towns.

General Account of the Fishing.

By common agreement among the fishermen, the Tay sprat fishing begins on the 25th of September and ends on the 25th of February.

This year's regular fishing, however, did not begin until the 20th of October, owing to the scarcity and poor quality of the fish.

The fishing boats are small yawls or smacks, from 38 to 48 feet along the keel, and manned by two, three, or four of a crew, the usual number, however, being two during poor seasons and three or four when fish are very plentiful. Each boat is valued at somewhere about £70, the net alone costing £12.

Some 29 boats are registered at the ports of Dundee and Perth, but the majority of these belong to Newburgh, St. Andrews, Easthaven, Carnoustie, Tayport, and Broughty-Ferry.

The boats go out either in the morning or afternoon, according to the abundance of fish or state of the tide, and fishing is continued throughout the night.

The fish are brought into the Dundee tidal-basin in the morning and are usually sold by auction, the auctioneer getting $3\frac{1}{2}$ to 4 per cent. of the gross return.

The fish are caught by means of a huge conical bag-net, which measures from 40 to 52 yards in length, with a mouth of from 21 to 24 feet square. I measured one as it lay stretched out on the quay and found it to be some 42 yards in length, with a mouth 23 feet square.

The mouth of the net is attached to two booms, an upper boom, 23 feet in length, which floats on the surface of the water, and a lower boom of the same length, weighted with iron, which sinks to various depths according to the strength of the tide.

The net consists of four parts, each part with a size of mesh smaller than the preceding part.

The first part attached to the two booms was 13 yards long, with a mesh of $1\frac{1}{8}$ of an inch from knot to knot, or, according to the fishermen, of 36 rows of meshes to the yard.

The second part is known as the "enter"; it measured 10 yards in length and had a mesh of $\frac{7}{8}$ of an inch from knot to knot, or, according to my informant, of 52 rows of meshes to the yard.

The third part of the net is known as the sleeve; it was 3 yards in length, with a mesh of $\frac{5}{8}$ of an inch, or 64 rows of meshes to the yard.

The fourth part of the net is known as the sprat-end; it measured 19 yards in length and had a mesh of $\frac{5}{16}$ of an inch from knot to knot, or, according to the fishermen, it contained 110 rows of meshes to the yard; the last three yards of the sprat-end were used as a tail end for hauling the net on board.

The Tay sparling fishing begins and ends at the same time as the sprat fishing, and is engaged in by the same men, who use the same boats and bag-nets but attach a small meshed herring-end or tail to the nets in place of the usual sprat end.

The sparling fishing is usually carried on when sprats and herring are not very plentiful in the river, and is usually confined to the upper parts of the estuary or from four to twelve miles above or west of the Tay Bridge.

The majority of the sprat and sparling boats are too old and rickety for any other kind of fishing except river-fishing. Their deck construction, accommodation, and gear are quite unsuited for winter herring fishing outside the river. A good many winter herring, however, are caught in the river along with the sprats and young herring during the months of January and February.

The sprat and sparling fishermen take part in various occupations during the summer time. Some of the men take part in the Tay salmon fishing; a few work on board the river passenger steamers, sand

boats, &c.; a few are tradesmen (masons, &c.); while the rest are general labourers.

Tay Sprat-Fishing Grounds.

The Tay sprat-fishing grounds are included in that part of the estuary extending from Invergowrie and Balmerino, some 3 miles above or west of the Tay Bridge, down to, or a little beyond, Tayport and Broughty-Ferry, between 4 or 5 miles east of the Tay Bridge.

From Broughty-Ferry, the estuary increases uniformly in width as far as 3 miles above the Tay Bridge, where it is $2\frac{3}{4}$ nautical miles wide.

At Dundee it is $1\frac{1}{4}$ nautical mile in width, and at Broughty-Ferry, some $4\frac{1}{4}$ miles below the Tay Bridge, the estuary is only $\frac{3}{4}$ mile across.

Many sandbanks extend over this particular part of the estuary, which are dry 4 to 7 feet at low water, the width of the navigable channel being about $\frac{5}{8}$ mile.

Sandbanks also exist in the main channel itself, composed of cleaner and coarser sand than most of the surrounding sandbanks. Contrary to expectation, the sandbanks of the Tay are found to vary very little in form from one year's end to another. Extensive flats and sandbanks are present on either side of the main channel above or west of the Tay Bridge.

Abreast of Invergowrie and Ninewells, the main channel is marked off by two red and two black buoys, and forms here a very important sprat and herring fishing ground.

About opposite the west end of Dundee an important sandbank exists, some 150 yards in width at low water. The deep channel on the south side of it formed the principal ground for this and last year's sprat and herring fishing. This particular sandbank is known as the Middle Bank, and its narrow east end is marked off by the Chequer buoy.

A somewhat variable and extensive shoal projects from the southern shore of the estuary, about half-way between Newport and Tayport; it is called the Newcome Spit, and consists of a mass of clean sand and shells six times as coarse as the Middle Bank. The neighbourhood of the Newcome Spit is also a favourite sprat and herring fishing ground.

At Broughty-Ferry there are no sandbanks, and the river here is fully 10 fathoms deep at low water.

Seaward of Broughty-Ferry the estuary widens rapidly, and the bottom consists largely of coarse sand full of rounded water-worn stones.

At Monifieth Bay this material is said to form a suitable spawning ground for winter herring.

Tides.

Spring tides flow up the river Tay as far as two miles above the city of Perth, and sprats and herring are got by the sparing fishermen as far up as Newburgh, but only in very small quantities.

Low water of ordinary spring tides at Dundee Harbour is 7.5 feet below ordnance datum, and high water of ordinary spring tides is $16\frac{1}{2}$ feet above that level. The extreme range of high water at Dundee varies between 19 feet 6 inches and 3 feet 7 inches, and extreme low tides sometimes fall 1 foot 5 inches below low water of ordinary spring tides.

The tides have an important bearing upon the quantity of fish caught in the river, and also restrict the fishing to those parts of the river where the currents are strong enough to open the bag-nets.

During the flood of neap tides the currents are too weak to open the nets, and fishing can only take place then during ebb-tide, while during

the height of spring tides the currents in the neighbourhood of Craighead and Newcome Spit are too strong, and occasionally damage or carry the nets away altogether.

Fishing is also entirely stopped for a short time, extending from half-an-hour to three-quarters of an hour, during the slack water between tides.

Many of the fishermen are of opinion that most of the fish enter the river during spring tides and make their way to the sea again as the tides slacken; this, however, was not borne out by the daily returns of the fishing during the past season.

The main mass of the flood tidal current, after sweeping through between Broughty-Ferry and Tayport, flows in the direction of West-Ferry Bay and the Stannergate, then south-west between the Chequer Buoy and the Newcome Spit. It next flows west between the Middle Bank and the Fife shore, then north again in the vicinity of the Tay Bridge to Ninewells and Invergowrie Bay. The returning ebb tide flowing in the opposite direction passes over much the same course.

All the important sprat and herring fishing-grounds lie in the above course, and the fish when not very plentiful in the estuary appear to always follow more or less these main tidal currents on their way from and to the sea. When the fish are very plentiful, on the other hand, they are caught in all parts of the estuary.

The presence of the flood tide is perceived on the north side of the estuary in several ways. First, the saltness of the water at spring tides upon the north shore is between 10 and 25 per cent. greater than that upon the south shore till the ebb tide has fairly commenced. Secondly, the current of the flood tide is so strong in the vicinity of Dundee as to give an inclination to the surface of the water, so that at half flood the level is 2 to 3 inches higher than it is on the opposite side of the estuary.

The deeper parts of both tidal currents are much salter and, during the cold months, warmer, than the surface waters; but there is generally a greater difference in salinity and temperature between the surface and bottom layers of water upon the flood than upon the ebb, these layers tending to intermix somewhat less upon the flood-tide than upon the ebb.

At the Abertay Lightship stationed at the mouth of the Tay, the saltness of the surface water, near low water and during heavy land floods, is sometimes as low as two-fifths of that of sea-water.

The normal ratio, however, of sea-water to land-water in the estuary is such that at the middle of its length—at Dundee—there is just as much fresh water as salt, and at the Pile Lighthouse, $\frac{1}{4}$ of a mile below Tayport, the quantities of sea-water and land-water are, on the average, as 2 to 1. The ratio of the land-water to sea-water at Dundee usually fluctuates between one-fifth and four-fifths.

So far as I can make out meanwhile, the movements of the sprats and herring in the river are not influenced to any marked extent by variations in temperature, although both kinds of fish appear not to wander very far from the slightly warmer water of the main flood tidal currents.

Some Notes on the Natural History of the Sprat and Winter Herring.

Sprats and winter herring frequent bays, inshore waters, and estuaries. They usually ascend the estuaries of rivers in large numbers during the months of October, November, December, January, and February. The main shoals appear to remain in the Tay estuary for short periods, extending from two to five or more days at a time, and then gradually make their way to the sea again.

Sprats and immature herring are amongst the most timid and restless of all fishes. They swim usually in separate shoals, but in the estuary of the Tay, where the main channel is so shallow and narrow, they very often mix and swim together.

Hardly any two fish in the sea have so many and varied enemies as the sprat and herring. This incessant persecution by numerous enemies, and consequent restlessness, may possibly partially account for the presence of both fish in such large numbers in the estuaries of rivers.

The fishermen, in trying to explain the presence of the fish in such large numbers in the Tay estuary, believe that the sprat and herring have a liking for brackish waters, and some scientists are under the impression that the fish seek the colder waters.

Several considerations, however, seem to be against such ideas. Both fish, while in the estuary, appear to remain in the main tidal currents, where the water is somewhat warmer than the surrounding waters. Experiments also show that in very cold waters fishes give up feeding altogether, probably because the ferments upon which digestion depends do not act, or at anyrate very slowly.

The fishermen also believe that the fish ascend the estuary to feed on the small organisms in the water, but this is also more or less erroneous. The majority of the herrings' stomachs examined were found to be empty; only a few contained a very small quantity of crustacea, while the sprats' stomachs were invariably found to be quite empty. Moreover, in the river at this season, the fish would get little or no food material to swallow, as careful examination of samples of water have shown.

Fishermen are also of opinion that the state of the tides is related to the quantity of fish in the river, that during spring tides the fish are more plentiful than during neap tides; but after carefully comparing the daily catches with the state of the tide, I am unable to show a close connection. Certainly on several occasions the best fishing was at or near the spring tides, *e.g.*, November 23, December 7 and 22, and January 17-21; but there was fairly good fishing during neap tides about November 1 and 15, December 27, and very good about January 12.

They, again, believe that rough weather, especially strong south-easterly gales, drive the fish into the river, but this also I am unable to prove.

During the great scarcity of fish in the month of November, I questioned many of the fishermen as to the state of the water in the river. One and all believed that they had never seen such a lot of fire (phosphorescence) in the river as during that time. This phosphorescence, along with the clearness of the water, enabled the fish to see the nets and thus avoid them. This I believe to be partially true, for if the fish swim in small, narrow, separate shoals, as they appear to do when not very plentiful in the river, then they might conceivably take fright at the glowing anchor and the chain, &c., and thus at the same time swim clear of the open mouth of the bag-net. Against this idea, however, is the fact that very seldom were the nets brought up absolutely empty, while nearly every boat managed to capture from $\frac{1}{4}$ to 3 crans of fish. During the daytime, however, it is a fact that little or no fish are caught if the water is very clear and the fish not very plentiful in the river. The fish avoid the light and swim at a much lower level, and thus avoid the open mouth of the bag-net.

IX.—GENERAL INDEX TO THE SCIENTIFIC REPORTS OF THE FISHERY BOARD FOR SCOTLAND, 1883–1904, WITH A LIST OF THE PAPERS CONTAINED IN THEM.
Prepared by Dr. THOMAS WEMYSS FULTON, F.R.S.E., Superintendent of Scientific Investigations.

For some years it has been felt as a want, both by the staff of the Board and by those engaged elsewhere in fishery investigations and research, that there existed no general index to the numerous scientific papers contained in the Annual Reports of the Fishery Board. These reports now number over a score, extending back to the year 1882, and they necessarily contain a large amount of matter dealing with marine biology and physics, and relating to fisheries and fishery problems. I have endeavoured to supply the want referred to by the compilation of the index and list of scientific papers printed in the following pages.

In the index the numbers referring to the various reports are enclosed within brackets; from the sixth report onward, that namely for 1887, the reference is to Part III. of the Annual Report, the reports since the year named being divided into three parts, the third of which is that devoted to scientific investigations. In the list of papers the figures in brackets refer to the year of publication.

LIST OF PAPERS.

Barrett, Dr. W. H.

Note on the Liver of a Haddock in which a Sand-eel was partly Embedded. **3**, p. 70, Pls. III.–V. (1885).

Beard, Dr. J.

On the Development of the Common Skate (*Raja batis*). **8**, p. 300, Pls. IX.–XI. (1890).

Brady, Professor G. S.

1. Notes on Entomostraca. **5**, p. 328, Pl. XIX. (1887).
2. Description of a new series of *Cyclops*. **6**, p. 232 (1888).

Brook, George.

- 1 and 2. On the Development of the Herring. **3**, p. 32, Pl. I. (1885); **4**, p. 31, Pls. I., II. (1886).
3. Note on some of the specimens sent in by the Officers of the Board. **3**, p. 67 (1885).
4. Report on the Herring Fishery of Loch Fyne and the adjacent districts during 1885. **4**, p. 47 (1886).
5. Report on the Food of the Haddock. **4**, p. 128 (1886).
6. Report on the Food of the Cod. **4**, p. 134 (1886).
7. Ichthyological Notes. **4**, p. 222, Pl. IX. (1886).
8. The Spawning-period of the British Food-fishes. **4**, p. 242 (1886).
9. Notes on the Food of Young Gadidæ. **5**, p. 326 (1887).
10. Notes on the Spawning of the Pike. **5**, p. 347 (1887).

Brook, George, and W. L. Calderwood.

Report on the Food of the Herring. **4**, p. 102 (1886).

Brook, George, and Dr. Thomas Scott.

List of the Marine Fauna collected at the Tarbert Laboratory during 1885. **4**, p. 231 (1886).

Calderwood, W. L.

1. Notes on the Copepods of Loch Fyne. **4**, p. 147 (1886).
2. Notes on the Greenland Shark (*Lamargus microcephalus*). **4**, p. 228, Pl. X. (1886).
3. Notes on an Intra-uterine specimen of the Porbeagle (*Lamna cornubica*). **6**, p. 263 (1888).

Clarkson, Dr. R. D.

On the Nutritive Value and Relative Digestibility of Fresh Fish. **5**, p. 221 (1887).

Cleve, Professor P. T.

Report on the Phyto-plankton collected on the Expedition of H.M.S. "Research," 1896. **15**, p. 297, Pl. VIII.

Cunningham, J. T.

Zones of Growth in the Skeletal Structures of Gadidæ and Pleuronectidæ. **23**, p. 125 (1905).

Daniel, Dr. Alfred.

Abstract of a Report on the Fishery Statistics of Scotland. **7**, p. 178 (1889).

Dannevig, Harold C.

- 1 to 5. Reports on the Hatching Operations at Dunbar Marine Hatchery during the Spring Season, 1894, **12**, p. 210 (1894); 1895, **13**, p. 123 (1895); 1896, **14**, p. 150 (1896); 1898, **17**, p. 205, Pl. VIII. (1899); 1899, **18**, p. 330 (1900).
6. The Influence of Temperature on the Development of the Eggs of Fishes. **13**, p. 147, Pl. I. (1895).
7. On the Rearing of the Larval and Post-larval Stages of the Plaice and other Flat-fishes. **15**, p. 175, Pl. IV. (1897).
8. Report on the Operations at Dunbar Marine Hatchery for the period July 1896 to December 1897, with some Notes on Rearing Experiments with Flat-fishes. **16**, p. 219 (1898).
9. On the Rate of Growth of Plaice. **17**, p. 232, Pl. IX. (1899).
- 10 and 11. Reports on the Hatching Work at the Marine Hatchery, Bay of Nigg, Aberdeen, during the Spring Season, 1900, **19**, p. 229 (1900); 1901, **20**, p. 440 (1902).

Day, Dr. Francis.

Note on a new Blenny (*Lumpenus lampetræformis*). **2**, p. 78, Pl. X. (1884).

Dickson, Dr. H. N.

1. Report on Physical Investigations carried out on board H.M.S. "Jackal," 1893-94. **12**, p. 336, Pls. XVI.-XIX. (1894).

Dickson, Dr. H. N.—continued.

2. Report on Physical Investigations carried out on board H.M.S. "Research" during August 1896. **15**, p. 280 (1897).

Duthie, Robert.

The Fisheries of Shetland. **10**, p. 202 (1892).

Edington, Dr. Alexander.

1. An Investigation into the Nature of the Organisms present in "Red" Cod, and as to the cause of the Red Coloration. **6**, p. 207, Pls. VI., VII. (1888).
2. On the Saprolegnia of Salmon Disease and Allied Forms. **7**, p. 368, Pl. IX. (1889).

Ewart, Professor J. Cossar.

1. Natural History of the Herring. **2**, p. 61, Pls. IV.–IX. (1884).
2. Note on some of the specimens forwarded by the Officers of the Board. **2**, p. 79, Pls. XI.–XIII. (1884).
3. Observations on the Spawning of Cod. **3**, p. 52 (1885).
4. Report on the Progress of Fish-culture in America. **3**, p. 78 (1885).
5. Are Herring Ova likely to Develop Normally on the Deep Offshore Fishing Banks? **4**, p. 43 (1886).
6. On the Artificial Hatching and Rearing of Sea-fish. **5**, p. 230, Pls. VII.–X. (1887).
7. Notes on the Nature of "Red" Cod. **6**, p. 204 (1888).

Ewart, Professor J. C., and Sir J. R. G. Maitland, Bart.

1. Report on the Trawling Experiments on the East Coast. **5**, p. 43, Pls. I.–III. (1887).
- 2 and 3. Reports on the Trawling Experiments of the "Garland," and the Statistics of the East Coast Fisheries. **6**, p. 25, Pls. I.–V. (1888); **7**, p. 15, Pls. I., II. (1889).

Ewart, Professor J. C., and J. Duncan Mathews.

On the Nature of Thames and Forth Whitebait. **4**, p. 98 (1886).

Ewart, Professor J. C., and Dr. T. Wemyss Fulton.

1. The Scottish Lobster Fishery. **6**, p. 189 (1888).
2. Report on the Spawning of the British Marine Food-fishes. **7**, p. 186 (1889).

Fletcher, John.

On the Tay Sprat Fishery, 1904–1905. **23**, p. 156 (1905).

Fryer, C. E.

The Preparation of Sprats and other Fish as Sardines. **5**, p. 218 (1887).

Fullarton, Dr. J. H.

1. Solway Shrimp and Flounder Fishings. **7**, p. 175 (1889).
2. On the Habits of *Pecten*, and on the Clam Beds of the Firth of Forth. **7**, p. 341, Pl. VIII. (1889).
3. Report on Bait Experiments. **7**, p. 352 (1889).
4. The Cockle Beds of Barra. **8**, p. 211, Pl. IV. (1890).

Fullarton, Dr., J. H.—continued.

5. Oyster-culture in France and Holland. **8**, p. 220 (1890).
6. On the Development of the Scallop (*Pecten opercularis*, L.). **8**, p. 290, Pls. V.–VIII. (1890).
7. On the Suitability of Scottish Waters for Oyster-culture. **9**, p. 184 (1891).
8. On Bouchôt Mussel-culture and the Bouchôt Experiments at St. Andrews. **9**, p. 212 (1891).
- 9 and 10. On the Development of the Plaice. **9**, p. 311, Pls. VII.–IX. (1891); **11**, p. 274, Pls. XIII.–XVI. (1893).
11. The Clyde Mussel Beds. **10**, p. 194, Pl. V. (1892).
12. On the Oviposition and Growth of the Lesser Sand-eel (*Ammodytes tobianus*, L.). **12**, p. 313 (1894).
13. On the History of Mussel-culture at Montrose during the past Six Years. **13**, p. 137 (1895).
14. On the Larval and Post-larval Development of the Brain of the Lesser Sand-eel. **13**, p. 276, Pls. XI.–XIII. (1895).
15. The European Lobster, Breeding and Development. **14**, p. 186, Pl. VI.–VIII. (1896).

Fullarton, J. H., and Dr. Thomas Scott.

- Mussel-farming at Montrose. **7**, p. 327, Pl. VII. (1889).

Fulton, Dr. T. Wemyss.

1. An Account of the Contemporary Work relating to Fisheries, including Abstracts of the more important Papers. **6**, p. 276 (1888).
2. Reports from Her Majesty's Diplomatic and Consular Officers Abroad on the best means of Increasing the Demand in Foreign Countries for Scotch-cured Herrings and other Fish. **7**, p. 158 (1889).
3. Abstract of Reports by Mr. Thomas Scott on his Special Investigations on board Steam Trawlers. **7**, p. 171 (1889).
4. Abstract of a Report by Dr. Alfred Daniell on the Fishery Statistics of Scotland. **7**, p. 178.
5. Inquiries into the Nature of the Food, the Spawning, Habits, &c., of Marine Food-fishes, **7**, p. 182 (1889).
- 6 to 18. Report on the Trawling Experiments of the "Garland," and on the Statistics of East Coast Fisheries. **8**, p. 22, Pls. I.–III. (1890); **9**, p. 21, Pls. I., II. (1891); **10**, p. 23, Pls. I. and II. (1892); **11**, p. 23, Pl. I. (1893); **12**, p. 23 (1894); **13**, p. 17 (1895); **14**, p. 17 (1896); **15**, p. 17 (1897); **16**, p. 17 (1898); **17**, p. 17 (1899); **18**, p. 19 (1900); **19**, p. 17 (1901); **20**, p. 17 (1902).
19. The Distribution of Immature Sea-fish, and their Capture by various Modes of Fishing. **8**, p. 157 (1890).
20. The Spawning and Spawning Places of Marine Food-fishes. **8**, p. 257 (1890).
21. The Proportional Numbers and Sizes of the Sexes among Sea-fishes. **8**, p. 348 (1890).
22. Notes and Memoranda. **8**, p. 351 (1890).
23. Notes on Contemporary Work relating to Fisheries in this and other Countries. **8**, p. 359 (1890).
24. The Chief Fishing Grounds on the East Coast of Scotland, with Charts showing their Position and Extent. **9**, p. 177, Pls. III., IV. (1891).
25. The Capture and Destruction of Immature Sea-fish. **9**, p. 201 (1891).

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26. The Comparative Fecundity of Sea-fishes. **9**, p. 243 (1891).
- 27 to 31. An Account of Contemporary Scientific Fishery Work and Fisheries in this and other Countries. **9**, p. 388 (1891); **10**, p. 327 (1892); **11**, p. 486 (1893); **12**, p. 383 (1894); **13**, p. 332 (1895).
32. On Over-fishing of the Sea and the Culture of Sea-fish. **10**, p. 171, Pls. III., IV. (1892).
33. Observations on the Reproduction, Maturity, and Sexual Relations of the Food-fishes. **10**, p. 232, Pl. VI. (1892).
34. An Experimental Investigation on the Migrations and Rate of Growth of the Food-fishes. **11**, p. 176 (1893).
35. An Account of the Sea-fish Hatchery at Dunbar. **12**, p. 196, Pl. I. (1894).
36. The Capture and Destruction of Immature Sea-fish. The Relation between the Size of the Mesh of Trawl-nets and the Fish Captured. **12**, p. 302 (1894).
37. The Capture and Destruction of Immature Fish. The Relation between the Size of Hooks and the Size of Fish Captured. **13**, p. 133 (1895).
38. The Relation of Marine Currents to Offshore Spawning Areas and Inshore Nurseries. **13**, p. 153, Pl. II. (1895).
39. Review of the Trawling Experiments of the "Garland" in the Firth of Forth and St. Andrews Bay in the years 1886-1895. **14**, p. 128, Pls. I., II. (1896).
40. The Past and Present Condition of the Oyster Beds in the Firth of Forth. **14**, p. 244, Pls. X., XI. (1896).
41. The Currents of the North Sea and their Relation to Fisheries. **15**, p. 334, Pls. X., XI. (1897).
42. On the Growth and Maturation of the Ovarian Eggs of Teleostean Fishes. **16**, p. 88, Pl. I. (1898).
43. The Ovaries and Ovarian Eggs of the Angler or Frog-fish (*Lophius piscatorius*) and of the John Dory (*Zeus faber*). **16**, p. 125, Pls. II., III. (1898).
44. On the Migratory Movements and Rate of Growth of the Grey or Common Gurnard. **17**, p. 210 (1899).
45. Report of an Inquiry on the Action of the Herring Seine-net. **18**, p. 242 (1900).
46. Additional Note on the Surface Currents of the North Sea. **18**, p. 370 (1900).
47. Investigations made on board Steam Trawlers. **19**, p. 58 (1901).
48. On the Rate of Growth of the Cod, Haddock, Whiting, and Norway Pout. **19**, p. 154, Pls. IX.-XVI. (1901).
- 49 to 53. Ichthyological Notes. **19**, p. 282 (1901); **20**, p. 539 (1902); **21**, p. 228 (1903); **22**, p. 281, Pl. XVIII. (1904); **23**, p. 250 (1905).
54. North Sea Investigations. **20**, p. 73, Pls. I.-III. (1902).
55. Rate of Growth of Sea-fishes. **20**, p. 326, Pls. XIV.-XXI. (1902).
56. Investigations on the Abundance, Distribution, and Migration of the Food-fishes. **21**, p. 15, Pl. I. (1903).
- 57 to 59. Reports on the Operations at the Marine Hatchery, Bay of Nigg, Aberdeen. **21**, p. 180 (1903); **22**, p. 262 (1904); **23**, p. 120 (1905).
60. The Distribution, Growth, and Food of the Angler. **21**, p. 186 (1903).
- 61 and 62. Trawling Investigations. **22**, p. 13 (1904); **23**, p. 13 (1905).

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63. On the Rate of Growth of Fishes. **22**, p. 141, Pls. VI.–XII. (1904).
64. General Index to the Scientific Reports of the Fishery Board for Scotland, 1883–1904. **23**, p. 166.

Fulton, Dr. T. Wemyss, and Dr. J. H. Fullarton.

Notes on Contemporary Work relating to Fisheries in this and other Countries. **7**, p. 384 (1889).

Gibson, Dr. John.

1. Report on the Physical Observations made for the Fishery Board for Scotland during the Autumn of 1883 in the Moray Firth. **4**, p. 189, Pls. VI., VII. (1886).
2. Report on Observations relating to the Physics and Chemistry of the North Sea during 1888 and 1889, and including a Review of the Analytical Work hitherto undertaken for the Fishery Board for Scotland. **7**, p. 409, Pls. X.–XIII. (1889).

Gibson, Dr. John, and Dr. H. R. Mill.

1. Report on the Apparatus required for carrying on Physical Observations in connection with the Fisheries. **6**, p. 309, Pls. IX., X. (1888).
2. Report on a Physical and Chemical Examination of the Waters in the Moray Firth, and the Firths of Inverness, Cromarty, and Dornoch. **6**, p. 313, Pls. XI.–XIV. (1888).

Gray, David.

Notes from Personal Observations on the Habits of the Greenland Whalebone Whale. **7**, p. 365 (1889).

Greenfield, Professor W. S., and Dr. John Gibson.

Further Report on the Examination of River Waters for Micro-Organisms. **5**, p. 331 (1887).

Greenfield, Professor W. S., and Dr. G. Sims Woodhead.

Further Report on the Examination of River Waters for Micro-Organisms. **4**, p. 176 (1886).

Halliburton, Dr. W. D.

On the Blood of *Nephrops norvegicus*. **4**, p. 171 (1886).

Heineke, Professor Friedrich.

The Natural History of the Herring. **17**, p. 274 (1899).

Herbertson, Dr. Andrew J.

Report on the Physical Observations carried on by the Fishery Board for Scotland during 1893. **18**, p. 302 (1895).

Hoyle, Dr. William E.

Report on the Biological Investigations on the Sea to the West of Lewis during July and August 1887. **6**, p. 215, Pl. XV. (1888).

Kyle, Dr. Harry M.

1. Report on the Pelagic Ova, Larvæ, and Young Fishes procured by the s.s. "Garland" during the greater part of 1896. **15**, p. 246 (1897).

Kyle, Dr. Harry M.—continued.

2. Note on the Reproductive Organs of a Hermaphrodite Ling. **15**, p. 396 (1897).
3. On the Post-larval Stages of the Plaice, Dab, Flounder, Long Rough Dab, and Lemon Dab. **16**, p. 225, Pls. X., XI. (1898).
4. Contributions towards the Natural History of the Plaice. **18**, p. 189, Pls. IX., X. (1900).
5. The Classification of the Flat-fishes (*Heterosomata*). **18**, p. 335, Pls. XI., XII. (1900).

Lawrence, George.

- Note on a Tumour found attached to the Stomach of a Saithe. **18**, p. 236 (1895).

M'Intosh, Professor W. C.

- 1 to 5. Reports of the St. Andrews Marine Laboratory. **2**, p. 47 (1884); **3**, p. 55, Pl. II. (1885); **4**, p. 201, Pl. VIII. (1886); **5**, p. 354 (1887); **6**, p. 265 (1888).
- 6 and 7. On the Pelagic Fauna of the Bay of St. Andrews during the months of 1888. **7**, p. 259, Pls. III.–VI. (1889); **8**, p. 270 (1890).
8. Report on the Pelagic Ova, Larval, and Young Food-fishes procured by the "Garland." **8**, p. 270 (1890).
9. Further Observations on the Life-histories and Development of the Food and other Fishes. **9**, p. 317, Pls. X.–XIII. (1891).
- 10 to 15. Contributions to the Life-histories and Development of the Food and other Fishes. **10**, p. 273, Pls. XVI., XVII. (1892); **11**, p. 239, Pls. VIII.–XII. (1893); **12**, p. 218, Pls. II.–IV. (1894); **13**, p. 221, Pls. VI.–VIII. (1895); **14**, p. 171 (1896); **15**, p. 194, Pls. V.–VII. (1897).
16. The Pelagic Fauna of the Bay of St. Andrews. **11**, p. 284 (1893).
17. Remarks on Trawling. **12**, p. 165 (1894).

MacLagan, Nellie.

- List of Edible British Fishes, with their English, Latin, French, Italian, and German Synonyms. **2**, p. 74 (1884).

Maitland, Sir J. R. G., Bart.

- Note on the Intercrossing of Members of the Genus *Salmo*. **7**, p. 382 (1889).

Masterman, Dr. Arthur T.

1. General Report on the Pelagic Eggs, Larval, and Young Fishes procured by the "Garland" in 1892 and 1893. **11**, p. 250 (1893).
2. On the Skeleton of the Tunny. **12**, p. 272, Pls. XI., XII. (1894).
3. On the Rate of Growth of the Marine Food and other Fishes. **13**, p. 289 (1895).
4. On Hermaphroditism in the Cod. **13**, p. 297, Pl. XIV. (1895).
5. On the Rate of Growth of the Food-fishes. **14**, p. 294, Pls. XII., XIII. (1896).
6. A Review of the Work of the "Garland" in connection with the Pelagic Eggs of the Food-fishes (1890–96). **15**, p. 219 (1897).

Matthews, J. Duncan.

1. Report on the Sprat Fishing during the Winter of 1883-84. **2**, p. 48, Pl. III. (1884).
- 2 and 3. Report as to Variety among the Herrings of the Scottish Coasts. Part I. **4**, p. 61 (1886); **5**, p. 295 (1887).
4. Note on the Ova, Fry, and Nest of the Ballan Wrasse (*Labrus maculatus*). **5**, p. 245, Pl. XI. (1887).
5. On the Structure of the Herring and other Clupeoids. **5**, p. 257, Pls. XV.-XVIII. (1887).
6. The Food of the Whiting (*Gadus merlangus*). **5**, p. 317 (1887).

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1. On the Physical Conditions of the Waters of the Firth of Forth. **5**, p. 349, Pls. XX.-XXIII. (1887).
2. Report of Physical Observations on the Sea to the West of Lewis during July and August 1887. **6**, p. 349, Pls. XV.-XVII. (1888).
3. Report on the Physical Observations carried on by the Fishery Board for Scotland in the Firths of Forth and Tay, and in the Clyde Sea Area. **9**, p. 353, Pls. XVI., XVII. (1891).
4. Report on Physical Observations bearing on the Circulation of the Water in Loch Fyne in April and September 1896. **15**, p. 262 (1897).

Mill, Dr. Hugh Robert, and Dr. Andrew J. Herbertson.

Report on the Physical Observations carried on by the Fishery Board for Scotland in the Firths of Forth and Tay, and in the Clyde Sea Area, as well as the Observations made on board the cruisers "Jackal" and "Vigilant" round the Scottish Coasts. **11**, p. 395, Pl. XVIII. (1893).

Milroy, Professor T. H.

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Murray, Dr. George.

Report on Observations on Plant-plankton. **15**, p. 212 (1897).

Murray, J.

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Norman, Rev. Canon A. M.

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The Echinoderms of the Moray and Cromarty Firths. **20**, p. 304 (1902).

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1. Notes on the Development of the Angler Fish (*Lophius piscatorius*). **9**, p. 343, Pls. XIV., XV. (1891).
2. Some Features in the Egg and Larva of the Skulpin (*Cullionymus lyra*). **9**, p. 349, Pl. XIII. (1891).

Prince, Professor E. E., and Dr. J. Lindsay Steven.

On two Large Tumours in a Haddock and a Cod. **10**, p. 323, Pl. XVII. (1892).

Sandeman, George.

1. On the Multiple Tumours in Plaice and Flounders. **11**, p. 391, Pl. XVII. (1893).
2. On a Tumour from a Tunny. **11**, p. 392, Pl. XII. (1893).
3. Parasitic Skin Disease in Montagu's Sucker. **11**, p. 393, Pl. XVII. (1893).
4. A Cod with one Eye. **11**, p. 394 (1893).
5. Notes on the Physiology and Pathology of Fishes. **12**, p. 291 (1894).

Scott, Dr. Thomas.

1. Notes on the Contents of the Stomachs of Herring and Haddocks. **6**, p. 225 (1888).
2. Description of a new Copepod. **6**, p. 232 (1888).
3. A Revised List of the Crustacea of the Firth of Forth. **6**, p. 235 (1888).
4. Notes on Interesting Fishes. **6**, p. 264 (1888).
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X.—ICHTHYOLOGICAL NOTES.

By Dr. T. WEMYSS FULTON, F.R.S.E., Superintendent of Scientific Investigations.

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THE YOUNG OF THE CONGER (*Leptocephalus*).

In last year's Report I described and figured two specimens of *Leptocephalus*,* both taken in the Moray Firth, one in December and the other in February. On 4th May last the Laboratory attendant, while using a small trawl of very fine netting, fitted on an iron frame, like a dredge-frame, for the capture of newly-transformed flat-fishes, caught a third specimen, and part of another. The drag was made in Aberdeen Bay, opposite the Bathing Station, in from four to five fathoms of water, and the fish in the net were brought ashore alive and placed in a tank in the tank-house at the Marine Laboratory. Next morning, on examining the tank, the *Leptocephalus* was discovered alive, concealed in a chink. Besides this living specimen, the head part of another of apparently the same stage and dimensions was found adhering to the net; it had been cut off about a centimetre behind the head, probably by the action of the edge of the iron frame dragged along the bottom. Other similar hauls in the same locality were made on succeeding days, but no other specimens were secured.

The living specimen was transferred to a large glass basin, on the bottom of which sand was strewn, and a stone with sea-weed growing on it was placed in the centre. Tow-nettings and also collections of crustacea from the beach, as well as minced mussels latterly, were placed in the tank. Here the young conger lived and thrived until 13th June, when it disappeared. It was observed by the attendant in the morning, but was missed a few hours later. The overflow was carried away by two S-shaped glass tubes, acting as syphons, and removing the water at a little distance below the surface. The bore of these tubes was about four millimetres in diameter, and it is not easy to understand how the *Leptocephalus* could have made its exit through either of them.

As it was desired to rear it if possible, it was not removed from the vessel for examination. So far as could be judged, it was about five inches in length and about a centimetre in breadth, and corresponded closely to the second of the two forms described last year, and identified as *L. punctatus*, of Kaup. The myotomes and the median row of black dots could be seen distinctly, but none were observed on the ventral margin. It was slightly whitish, but translucent and almost trans-

* *Twenty-Second Annual Report of the Fishery Board for Scotland.* Part III., p. 281.

parent, and its eyes were the only conspicuous part of it, the silvery lustre contrasting with the intense black pigment, of which there was also a somewhat triangular patch on the upper surface.

At first it habitually lurked in concealment under the overhanging edge of the stone, only its head being visible. On being disturbed its first movement was to withdraw the head also, but if the disturbance continued, it came out from its lair and swam slowly round the vessel, close to the sand, with an undulatory or serpentine movement, stopping every now and again and swaying its head to one side or the other as if examining the bottom, which it occasionally tapped suddenly with its snout. Later, it took up a position on the top of the stone, among the weeds, with its body entwined among the stems.

In the part of the other specimen, examined later after preservation in formaline, the depth behind the head was 6mm. and the thickness 3mm., the diameter of the eye being 1.5mm. The lower jaw was conspicuously longer than the upper, projecting considerably beyond it; minute dots of dusky pigment existed on the tip of the snout, and still more markedly on and around the tip of the lower jaw, extending backwards under it. The tissues had a solid consistence. This specimen thus appears to differ somewhat from the one I described last year.

THE ANCHOVY (*Engraulis encrasicolus*).

In some previous reports I have described the occurrence of the anchovy in Scottish waters.* On 29th June, last year, a specimen was taken in a sparling (or smelt) net, near Creetown, Wigton Bay, and was sent by Mr. W. Poole, of that place, to Mr. R. Duthie, the Fishery Officer of the district, whom I have to thank for the specimen. Compared with other Scottish specimens that have come into my hands, it is unusually large. The end of the tail is damaged, and its length, as it is, is 178mm., or 7 inches, but when perfect it probably measured about 184mm. According to Day, the anchovy rarely exceeds 6½ inches, but he mentions that Dunn has obtained specimens off the Cornish coast measuring eight inches in length.

THE CATFISH (*Anarrhichas lupus*).

The spawning period of this fish has not yet been well determined; it may therefore be worth while recording that on 6th August last, among a number which were caught by a trawler in 49 fathoms, six miles north-west of Foula Island, which lies to the westwards of the Shetlands, some of the females had the eggs well advanced. The fish were opened by Captain Samuel Caie and the eggs were sent in bottles to the Marine Laboratory. In three cases the eggs measured from 3mm. to 4mm. and were obviously immature, but in one instance they were fully mature, measuring 6mm., and they were isolated and separate, and apparently ready for extrusion.

M'Intosh and Masterman† are probably right in supposing that the main spawning time of this fish is from November to January, with a margin on either side; but the existence of a fully ripe female at the beginning of August shows that spawning may begin much earlier than November.

AN ALBINO PLAICE.

I am indebted to Mr. James Robb for a specimen of an albino plaice

* *Eighth Annual Report of the Fishery Board for Scotland*, Part III., p. 351 ;
Twentieth. ibid., p. 539.

† *British Marine Food Fishes*, p. 201.

which was caught by the steam trawler "Chinkiang," 25 miles S.-E. by E. from Aberdeen in March last, and which was received alive at the Marine Laboratory. It was $14\frac{1}{2}$ inches in length and was everywhere destitute of pigment, except on the upper surface of the head and gill-cover and at the root of the ventrals, where a small patch existed. The ocular side was as white as the blind side. The fish was put into a tank along with other flat-fishes and was exceedingly conspicuous as it lay on the bottom. It lived for over two months and was found dead on 19th May.

In the Report for last year* I described another albino plaice, so that they are not extremely rare.

The specimen above described was interesting also as giving an example of the tenacity of life in this species. It was caught by the "Chinkiang" about two in the morning, put with the other plaice and brought to market; it was being packed in a box in the usual way about ten o'clock, when it was discovered by Mr. Robb, who sent it to the laboratory in fresh water as preferable to the impure water of the harbour.

THE SPAWNING OF THE COD IN AUTUMN IN THE NORTH SEA.

Under this title, I contributed last year to the *Publications de Circonstance* (No. 8, 9) of the International Council for the Exploration of the Sea, a paper in which I described the occurrence of shoals of spawning cod in autumn, on a ground known as the "Reef," lying about 180-190 miles E. by N., or E. by $\frac{3}{4}$ -N., from Aberdeen, that is to say, close to the deep water of the Norwegian Channel, and about seventy or eighty miles from the coast of Norway. A few additional observations on the subject may be here mentioned.

Last year the fishing on this ground was begun about the middle of July by one of the steam liners (the "Vigilant"), and later by others, and it was continued till late in the year. Mr. Forbes, the skipper of this vessel, informed me that the grounds on which they were fishing were situated 195 and 196 miles E. $\frac{3}{4}$ -N. from Aberdeen in 55 and 56 fathoms of water. He states that there is another patch of rough ground about 50 miles to the northwards where they also get spawning cod in autumn. In August I noticed the ripe cod in the fish-yards and traced them to the "Reef" grounds, and I got Mr. Forbes to keep a tally of the cod taken on two of his voyages. The first occasion was 30th August and the position was 165 miles E. $\frac{3}{4}$ -N., the depth being 56 fathoms. The number of cod caught was 18 score, or 360 fish, and the number from which the milt or eggs were observed to be running as they were brought on board was 37 males and 28 females, or nearly 19 per cent. On this occasion, I was informed, the vessel was not quite on the proper grounds; they were a little too far north and, owing to fog, they were unable to see the sun to determine their position. When on the right ground, they say that practically all the cod taken are either spawning or full, or spent. The next occasion was the 14th September, the position being nearly the same, viz., 196 miles E. $\frac{3}{4}$ -N., and the depth 55 fathoms. Forty-one score of cod, or 820 fish, were taken, and the number observed to be "running" was 83 females and 67 males, or again nearly 19 per cent. One or two ling were also found to be spawning, but as a rule they were beginning to "fill up."

It is of interest to note that the largest average catches of cod obtained by the Aberdeen steam-liners are taken from the area in

which these grounds are situated. The statistics of the vessels in 1903, for which I am indebted to Professor D'Arcy Thompson, show the following, in cwts. per 100 lines used, for Square XX., in which the "Reef" lies:—

And the complete statistics for the various Squares in the North Sea, in which the vessels fished in the last five months of the year are these:—

352

3

2254

72

72

Square XXV., it may be said, lies to the south of XX., contiguous with it.

Dr. Hjort, of the Norwegian Fishery Board, who visited the grounds in the "Michael Sars," the Norwegian investigation steamer, last August, has pointed out as an interesting fact that the temperature at the place where the spawning cod are found in autumn is the lowest for the year in the locality, while on the coastal banks, where the spawning takes place in spring, the temperature is also at the lowest during the spawning time.

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